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GEOLOGICAL AND NATURAL HISTORY SURVEY OF CANADA

ALFRED R. C. SELWYN, LL.D., F.R.S., F.G.S., DIRECTOR.

REPORT

ON THE

CYPRESS HILLS WOOD MOUNTAIN

AND

ADJACENT COUNTRY,

EMBRACING THAT PORTION OF THE DISTRICT OF ASSINIBOIA, LYING
BETWEEN THE INTERNATIONAL BOUNDARY AND THE 51ST
PARALLEL AND EXTENDING FROM LON. 106°
TO LON. $110^{\circ} 50'$.

BY

R. G. McCONNELL, B.A.



PUBLISHED BY AUTHORITY OF PARLIAMENT.

MONTREAL:
DAWSON BROTHERS.
1885.

To ALFRED

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January, 18

To ALFRED R. C. SELWYN, Esq., LL.D., F.R.S., F.G.S.,
Director of the Geological and Natural History Survey of Canada.

SIR,—I have the honour to present herewith a report, accompanied by illustrative maps and sections, on the geology and general resources of the Cypress Hills, Wood Mountain, and adjacent territory, embracing part of the District of Assiniboina. It treats of the country lying immediately east of the Bow and Belly Rivers District previously reported on by Dr. G. M. Dawson, and forms the second of a series designed eventually to cover the whole North-west Territory.

I have the honour to be,
Sir,
Your obedient servant,
R. G. McCONNELL.

January, 1886.

NOTE.

All the elevations, with the exception of those along the Canadian Pacific Railway, which were obtained by instrumental levelling, are the result of aneroid barometer readings, corrected by comparison with the regular barometric observations kept at Medicine Hat and Qu'Appelle.

The bearings are always with reference to the true meridian.

The invertebrate fossils mentioned in the following report have in all cases been determined by Mr. J. F. Whiteaves.

The following table shows the elevations of the stations along the railway line from Qu'Appelle to the Canadian Pacific Railway, and the distances between them.

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REPORT
ON THE
CYPRESS HILLS WOOD MOUNTAIN
AND ADJACENT COUNTRY.

The following report treats of that portion of the district of Assini-
boia lying between the international boundary and the 51st parallel,
and extending from the third principal meridian to range VI. west of
the fourth, or from longitude 106° W. of Greenwich to 110° 50'.
It embraces an area of about 31,000 square miles, and is accompanied
by a geological and topographical map of the same district. The
northern part of the map has been reduced from the township plans of
the surveys made by the Dominion Lands Department, the only changes
made being in the shape and contour of the ridges and other elevations.
These are so intimately connected with the geology in a country
where the beds are almost horizontal, that they demanded special
attention. The topography of the southern part of the district, as laid
down on the map, has been obtained chiefly by odometer traverses made
by myself in the summer of 1883 and by Mr. D. B. Dowling in the
summer of 1884. The surveys of H.M. North American Boundary Com-
mission, along the 49th parallel, have also been incorporated in this
part of the map.

The country in the immediate vicinity of the 49th parallel was
examined and reported on by Dr. G. M. Dawson, in 1874, while connect-
ed with the Boundary Commission, but in regard to all the rest of
the district, very little trustworthy geological information was avail-
able before the present exploration was undertaken. In fact, the only
work done is included in a hasty trip made by Dr. Hector to the west
end of the Cypress Hills, in 1859, and a few notes collected by Pro-
fessor Hind in regard to the geology of the country near the Elbow of
the South Saskatchewan; that point being the western limit of his
work while in charge of the Assiniboine and Saskatchewan exploring

Previous explo-
rations.

expedition in 1858. Dr. Bell also visited the Elbow and a few other places along the eastern edge of the district in 1874.

Time occupied by present exploration.

Character of report.

Elevations.

Absence of intrusive rocks.

Cause of surface irregularities.

Extent and character of plains.

The present exploration has occupied the seasons of 1883 and 1884. But as a great part of the time has necessarily been spent in the collection of topographical details, it may easily be seen that the remainder was insufficient to enable me to delineate in more than a general way, the main geological features of so extensive an area. The present report, therefore, cannot pretend to be much more than preliminary in its scope.

PHYSICAL FEATURES.

The district of which this report treats forms part of the third great prairie steppe. It has a general elevation in its eastern part, north of the main divide, of about 2,200 feet. Near the western limit of the map this increases to about 2,500 feet, though parts of the Cypress plateau rise over two thousand feet higher. It includes, besides an extensive area of prairie country, the Cypress Hills plateau, the western part of Wood Mountain, and a number of smaller plateaus intervening between these two. The Missouri Côteau crosses its north-eastern corner. This country lies so far from the mountains, that it has escaped being affected to any appreciable extent by the disturbing forces which have been so active there. No intrusive rocks are met with in any part of the district, and the beds are either horizontal, or are subject to dips of the easiest description, scarcely ever exceeding ten or fifteen feet to the mile. Consequently, all the main surface irregularities have been caused entirely by the varying degrees of resistance which different parts of the area have been able to offer to the denuding agents.

Only two kinds of country are represented in the district (1) Plains, (2) Plateaus. There are three distinct plains separated by well-defined boundaries. The largest one lies to the north, and extends from the Cypress Hills plateau to the South Saskatchewan and beyond, and from the western limits of the map east to the Côteau. This plain is by no means uniform in character; while in some places almost perfectly level, in other parts it becomes boldly undulating and even hilly, and is further diversified by numerous extensive areas of drifting sand-hills. It slopes north-eastward to the South Saskatchewan, to the basin of which it belongs, though that river receives from it but scanty addition to its volume, as most of the streams flow into large lakes where their waters are evaporated. The second plain occupies the country between the Cypress Hills, the White Mud River plateau, and the boundary. Near the eastern end of the Cypress Hills it is almost cut in two by a spur which that plateau sends southward. The western

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part of this plain is extremely barren. The soil is a stiff grey clay, studded with pebbles and boulders, and produces nothing but cactus, with here and there a blade of *Stipa*, or other drought-loving grass. Eastward, the clay is replaced by a more loamy soil, and the plain becomes better grassed. The third plain extends south and east from Old Wives' Lake, and occupies a basin-shaped depression between the Côteau, Wood Mountain, Pinto Horse Butte, and the Swift Current Creek plateau. It is much smaller than the others, and is drained by the numerous branches of Old Wives' Creek into Old Wives' Lakes. In the north-eastern corner of the map a small part of the second prairie steppe is included within the limits of the present report. All the plains mentioned are underlaid by rocks of Cretaceous age, but these seldom appear on the surface, being usually concealed by a covering of drift which is often upwards of 200 feet thick.

The plateaus are best developed in the southern and eastern part ^{Age of} _{plateaus.} of the district. With one or two unimportant exceptions, they are all of Laramie or Miocene age. The existing Laramie plateaus represent a former much greater one, which must at one time have stretched at least, from the Bud Buttes to the present Laramie plateau of Wood Mountain, and covered the whole country between the Cypress Hills and the Côteau. This area has been worn away on the south by tributaries of the Missouri, and on the north by streams flowing into the Saskatchewan, or into the pre-glacial representatives of these streams, until it has assumed its present limited proportions. The work of demolition, though greatly checked, is still being carried on by the White Mud River, Swift Current Creek, and a few other smaller streams. The principal plateaus of the district are the Cypress ^{Principal} _{plateaus.} Hills, Swift Current Creek plateau, the White Mud River plateau, Pinto Horse Butte, Wood Mountain, and part of the Côteau. A brief description of each of these will be given later on, but before proceeding to that part of the subject, a few words in regard to the capabilities of the district in general may not be out of place.

Until within the last few years, that portion of the territories covered by the present report was regarded as almost a desert, and was thought to be entirely unfitted for settlement. The results of the experimental farms instituted by the Canadian Pacific Railway Company last summer (1884), which were, almost without exception, eminently successful, have been instrumental in dissipating this idea in regard to a large proportion of the district. It nevertheless, remains true, that there are extensive tracts of country in this part of the North-west which are wholly worthless. The desolate and repulsive region south of the west end of the Cypress Hills can never be utilized for any purpose, while in the great plains lying north of these

Agricultural
value of
district.

Results of
experimental
farms.

hills, the area covered by bare drifting sand-hills amounts to an appreciable part of the whole. The plateaus, though no doubt valuable for pastoral purposes, are too high and cold for the growth of cereals, and the same thing holds good in regard to the Côteau and the hilly country associated with it.

The best part of the district undoubtedly lies to the north along the Saskatchewan. Commencing near the mouth of the Red Deer, extensive plains of level or slightly undulating country border this stream on the south, and extend all the way to within a few miles of Swift Current Creek. These plains are little, if at all inferior from an agricultural standpoint, to the best lands east of the Côteau. Among the other more important areas of good land, I may mention the plains lying a few miles west of the southern portion of Old Wives' Lakes, the plains around Reed Lake, and the country near Maple Creek. Taking the district generally, barely one-half, even under the most liberal estimate, could be classed as suitable for agricultural purposes; a large proportion of the remainder is however well fitted for stock-raising, the parts ranking highest in this respect being the northern slopes of Wood Mountain and the country in the vicinity of the Cypress Hills.

GENERAL DESCRIPTION OF THE DISTRICT.

THE CYPRESS HILLS.

Elevation and
trend of
Cypress Hills.

Surface.

The Cypress Hills plateau forms the largest and most important member of a system of uplands which, though usually at wide intervals, are everywhere irregularly distributed over the plains. Commencing about 30 miles south of Medicine Hat, where it attains an elevation of 1,200 feet above the plains at its base, or about 2,700 feet above the level of the Saskatchewan at Medicine Hat, it extends eastward, though with gradually diminishing height, for a distance of eighty miles. It ends on its northern and western sides in a bold scarp, varying in height from 1,000 feet to about 500 feet. This escarpment does not end with the hills, but continues on in a direction a little north of east to Swift Current Creek. On the south, the plateau, west of Battle Creek rises from three to four hundred feet above the plains. East of that point, the hills, except for short distances, have no distinct edge, the plain rising up to the level of the plateau with a long easy slope. The surface of the Cypress Hills plateau, west of the Four-mile Coulée, is, except where cut by the deep cañon of Battle Creek, very smooth and even, and has a gentle slope eastward of about twelve feet to the mile. East of Four-mile Coulée it becomes more rolling and irregular.

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to an appreciable value for cereals, and in the country north along the Red Deer, border this a few miles all inferior to the Côteau, may mention Old Wives' Maple Creek, for the most purposes; for stock-breeding in the northern vicinity of the T. important intervals, are being about 1,200 feet above the level of the ground, gradually rising from the Swift Current River, which rises from point, the main rising surface of the prairie, and even, and East of

An important feature in the general outline of the plateau, and one which is of great assistance in the elucidation of its geology, is the number of coulées which cross it transversely. Two of these, viz: Medicine Lodge Coulée, and another valley at the east end of the hills, part of which is now occupied by a tributary of Swift Current Creek, must have been excavated in early post-glacial times, as the present grass-covered condition shows that the inconsiderable streams by which they are now occupied are doing very little erosive work. Each of these valleys is now occupied by two streams, one draining to the north and the other to the south. Near the centre of the hills a depression of about seven miles wide, and from three to four hundred feet deep, crosses from north to south. This hollow is called the "Gap," and is evidently of sub-aqueous origin, as it shows no indications of ever being the bed of a stream of any size. It lies immediately east of the unglaciated part of the hills and was probably produced by a current in the glacial sea, sweeping round that part of the plateau which remained unsubmerged. The "Gap." The "Gap."

The drainage of the hills is nearly all to the south and east, the principal streams concerned, being Battle Creek, and the White Mud River, both tributaries of Milk River, and Swift Current Creek, which flows north-east to the Saskatchewan. The White Mud River and Swift Current Creek, both head near the south-east corner of the hills, where they spread out into a plexus of coulées, often inoculating one with another, and are carrying on the work of demolition with great rapidity. The streams flowing north from the hills are insignificant in size, and with the exception of Ross Coulée, which flows into the Saskatchewan at Medicine Hat, empty into lakes which are all more or less saline, and have no present outlets.

The height of the Cypress Hills plateau, which at its western end is nearly five thousand feet above the sea, gives it so cold a climate as to render it almost valueless for anything except stock-raising. But for this purpose it seems especially adapted, as it possesses all the necessary requisites in a high degree. The snow-fall is light, and grass, water and shelter are everywhere abundant.

I quote the following in regard to the flora of the Cypress plateau from Professor Macoun.*

"The flora of the Cypress Hills is very remarkable, and differs in many respects from that of the plains. In the coulées which extend into the hills on the north and east sides, the vegetation is almost exclusively eastern, and contains numerous forest species, while that of the plateau above, and the upper slopes of the hills have the prairie features of flora. Rocky mountain features of flora.

* Manitoba and the Great North-west, p. 192.

of the Rocky mountain flora, and both alpine and boreal species here find a home.

"In the upper part of the coulées amongst the spruce at the eastern end were *Spiraea betulifolia*, *Geranium Richardsonii*, *Habenaria rotundifolia*, *Phleum alpinum*, *Arenaria congesta et verna*, *Delphinium Menziesii*, and on the exposed gravel points and ridges that rose almost perpendicularly, were *Astragalus pauciflorus*, *Sedum stenopetalum*, *Cetraria nivalis aculeata et Islandica*, *Polygonum imbricatum*, and *Vesicaria montana*. In the deep coulées, around springs of purest water, were large patches of *Mimulus luteus*, covered with a profusion of yellow flowers, and amongst the common sedges were *Carex festiva* and *capillaris*. These all mountain species, and numerous others known to dwell there, told a tale that the botanist alone could understand. Whether the Cypress Hills were an outlier of the Rocky Mountains or not, their flora indicated that their climate was that of the foot-hills above Morley, and necessarily unfit to regularly mature cereals, although in sheltered valleys, barley and potatoes could possibly be raised.

"The grasses of the plateau were of the real pasturage species and produced abundance of leaves, and were so tall that for miles at a time we had great difficulty in forcing our way through them. The chief were species of *Festuca*, *Danthonia*, *Poa*, *Avena pratensis*, *Bromus* and *Phleum alpinum*, and although their seeds were all ripe (August 14th,) their leaves were quite green.

"As we proceeded westward over the plateau, it became more elevated and other species began to take prominence, notably *Lupinus argentea* and *Potentilla fruticosa* covered miles of country, to the exclusion of other species, and as both grew about eighteen inches in height, and had a bushy habit, the whole country, for a day's travel, was either blue or yellow or both, as either species prevailed or were intermixed. In all my wanderings I never saw any spot equal in beauty to the central plateau of the Cypress Hills.

"The grasses and other forage plants of the hills were those peculiar to coolness and altitude, but were all highly nutritious, and almost identical with those found on the higher plateaus at Morley. In all the valleys, and on the rich soil of the higher grounds, the grass was tall enough for hay. No better summer pasture is to be found in all the wide North-west than exists on these hills, as the grass is always green, water of the best quality always abundant, and shelter from the autumnal and winter storms always at hand."

"The pasturage of this region is identical with that on Bow River, and the climate seems just as dry, and I was informed that it felt the influence of the winter chinooks to some extent likewise."*

Cold climate indicated by flora.

Nutritious character of grasses.

Chinook winds.

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* Ibid, p. 252.

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There seems to be no reason to doubt that the chinooks are felt as far east as the Cypress Hills, as the testimony of all the settlers to whom I spoke on the subject, was unanimous in regard to their occurrence at least two or three times every winter.

The supply of timber on the hills is considerable, more especially fuel supply, near their western end, where there is quite a large area covered with coniferous trees, and in other parts the coulées are all more or less wooded. There is also an abundant supply of fuel, of a different kind, as the lignite seam, which occurs near the base of the Laramie, is exposed in nearly all the large coulées. This seam varies in thickness from a maximum of five feet, and affords lignite of a very fair quality.

PLAINS SOUTH OF THE CYPRESS HILLS.

The range of plateaus which extends in an irregular manner from Sage Creek to Bull's Head, is bordered on the west by comparatively level plains, reaching to the western edge of the map and beyond. These plains are underlaid by rocks belonging to the Belly River series, and have an average height of about 3,000 feet. They are usually very barren, except towards Milk River, where the soil becomes better and supports a tolerable growth of short grass. From the edge of the plateaus east to Willow Creek the surface is broken by creeks and coulées flowing in a westerly direction. Willow Creek occupies an old valley which connects the drainage systems of the Missouri and the Saskatchewan, and separates the Bud Buttes from the Cypress Hills. Near the "Head of the mountain" this valley is well up on the slope of the hills, and going west from it, the country, in a few miles, descends below the level of its bottom. East of Willow Creek, along the base of the hills, the surface becomes very irregular, and is furrowed in all directions by a multitude of branching coulées flowing from the hills. Most of these coulées become united with Willow Creek before reaching the boundary line. Near the boundary a level or lightly undulating plain extends from Milk River to Boundary plateau. The soil underlying this plain is usually a stiff clay or hard loam derived from the underlying boulder-clay, and is, as a rule, hopelessly barren. Its sun-burnt surface, studded with small boulders, and split in all directions by shrinkage cracks, is scantily clad with a scattered growth of *Artemisia* and *Cactus*, separated by a few scattered blades of *Stipa sparteo*. On some of the higher grounds the vegetation becomes somewhat improved, and the *Stipa* is associated with buffalo grass (*Bouteloua oligostachya*). The plain is drained by two branches of Milk River, which, with their tributaries, wind through wide shallow valleys, enclosing desolate sage-covered bottoms, which are forbidding

Plain west of

Boundary

plateau.

Vegetation.

Drainage.

in the extreme. Both of these streams are intermittent, and during the dry season hold water in pools only. North of this plain and south of Cypress Lake a sandy area of considerable extent occurs which is much better grassed.

These plains are bounded on the east by a wide ridge, which, with one or two short breaks, extends from the Cypress Hills to the boundary. The northern part of this ridge is connected with the Cypress Hills, and is covered with high rolling hills, built principally of drift, which have a very côteau-like appearance. They extend south, but with somewhat diminished altitudes, to the edge of Old-man-on-his-back plateau.

Old-man-on-his-back plateau and Boundary plateau, like most of the uplands in this region, are both well grased, and in this respect, present a pleasing contrast to the sterile plains which stretch west from their base. They are of inconsiderable area, and towards the east, soon descend to the level of the plain which lies between the White Mud River and the boundary line.

This plain contains an area of about 1,300 square miles, and has an average height of about 3,000 feet. It is usually more or less undulating, and occasionally swells into comparatively high ridges. Its soil is a hard bouldery clay-loam, or pure clay, and is usually rather barren, though in some places it supports a fair vegetation.

PLAINS EAST OF THE CYPRESS HILLS.

Valley east of Cypress Hills.

Connects northern and southern drainage systems.

Remarkable hills and ridges.

The Cypress Hills are bordered along their eastern margin by a wide grass-grown valley, which is now followed in different parts by three separate streams, none of which, however, seem to have been its original occupant. Like the valley of Willow Creek, it forms a connecting link between the northern and southern drainage systems. Its eastern bank is much lower than its western one, and opens on a wide shallow depression, which extends to the western edge of Swift Current Creek plateau. This flat is mostly based on Fox Hill sandstone, and is very thinly covered with deposits of glacial age. It supports a fair vegetation. The plain north of it on both sides of Swift Current Creek, is dotted at intervals with small steep-sided conical hills built apparently of drift, either standing alone or united in short ranges, which are usually more or less curved in shape, and sometimes form complete circles. These hills look like miniature mountains and mountain-ranges, and are entirely different from any that I have seen elsewhere on the plains. They vary in height from thirty up to seventy-five feet.

Going in an easterly direction, the two low spreading plateaus of Swift Current Creek and White Mud River are next met with. Both

of these are sandy. They are sparsely covered, their slopes being covered with Woodland, White Mud, and divided up by Willow Creek, on the eastern side, which extends over a more level tract of valley.

Going eastward rapidly and across the western edge of the plateau, branches of the river, square miles in area, soil is a sandy loam. Old Wives' tale says that a good deal of the ground acquires a

Woodland, which it is said, is the principal forest of the region, about forty miles to the north. It is sometimes called Post and Pine, and is miles wide, and very irregular, showing on the surface which are covered with Cypress trees, and is much greater than it is now, in fact, the plateau is

of these possess well-grassed, and more or less undulating surfaces. They are separated by the Middle Branch of Old Wives' Creek, towards which they present a somewhat abrupt face, but in other directions their slopes are generally very easy. The latter plateau is connected with Wood Mountain by a ridge which skirts the northern bank of White Mud River. The eastern part of Swift Current Creek plateau is divided up into a number of spurs, separated by branches of Old Wives' Creek, on some of which there are small groves of poplar. North of the eastern end of this plateau is a region of very high rolling hills, which extends nearly to Reed and Rush Lakes, where it is replaced by a more level country. Around these two lakes there is a considerable tract of very fair land.

Going east from Swift Current Creek plateau, the country falls ~~wide plain~~ rapidly and spreads out into a wide plain, which extends east to the western edge of the Côteau. This plain is drained by the different branches of Old Wives' Creek, and contains an area of over 1,200 square miles, most of which is suitable for agricultural purposes. The soil is a sandy or clay loam of superior quality. The middle branch of Old Wives' Creek, which flows through the centre of the plain, contains a good deal of wood in places; chiefly ash-leaved maple. (*Nemundo aceroides*.)

WOOD MOUNTAIN PLATEAU.

Wood Mountain plateau—the second largest in the district—is connected with the Laramie area of the Côteau and Souris River, of which it forms the westernmost part. It extends from the third principal meridian westward to the White Mud River, a distance of about forty miles, then bending more to the north it continues on to the middle branch of Old Wives' Creek, a further distance of about forty miles. The southern part of this north-western extension is sometimes called Pinto Horse Butte. Between Wood Mountain Post and the third principal meridian the plateau is about thirty miles wide, and has a height of about 3,200 feet. Its surface is ^{Extent of Wood Mountain.} very irregular, and is channelled in all directions by deep and wide coulées, the banks of which are usually grass-covered, and show only occasional exposures. These large coulées, many of which are now almost waterless, in common with similar ones in the Cypress Hills, imply a time when the rainfall must have been very much greater than at present. There is little or no denudation going on now, in this part of the plateau, and the present surface configuration must have been assumed long ago. West of Wood Mountain Post the plateau narrows in, and both its northern and southern slopes be-

come more abrupt. From this point on to its western end it seldom exceeds five or six miles in width, and is often much less. Its outline is sinuous and irregular, and consists of spurs thrust out between the various streams, alternating with deep bays. In some places it has been cut across by inoculating coulées. The surface of the plateau, where not broken up by coulées, is usually smooth or only slightly undulating, but near its western end it becomes very rolling and hilly, so much so as in some places to bear a strong resemblance to the Côteau country.

Suitable for
grazing.

Wood Mountain plateau and the country in its vicinity, like the Cypress Hills, is everywhere well grassed and well watered, and will, at no distant day, be extensively used as a grazing country. The wood supply is small, and is confined to the large coulées and to the edge of the plateau; but on the other hand, good lignite in large quantities can be obtained within easy reach of any part of the plateau.

Eastern edge
well marked.

Height.

Western edge.

Extent of hilly
country.

Flat plain
north of
Saskatchewan.

The Côteau enters the district covered by this report, north-east of Old Wives Lake, and crosses it in a north-westerly direction.

In this part of its course, while it preserves most of the distinctive features which characterize it elsewhere, it becomes very broad and diffuse, especially towards the Saskatchewan, and its western boundary is very difficult to define. Its eastern edge is well marked by an escarpment, which is 500 feet high where crossed by the trail between Moosejaw and Wood Mountain, but, going northward, this height decreases to about 300 feet at Secretan, and near the river to about 200 feet. North of the river it increases again to over 300 feet. The line of this escarpment is indented by a number of deep bays, and its slope, though usually easy, becomes in some places very abrupt.

The western edge of the hilly country crosses Old Wives' Lake, a few miles from its southern end, and then runs westward, south of Rush and Reed lakes to Swift Current Creek, which it crosses near Lonmay. From Lonmay it continues on to the Saskatchewan, which it reaches about ten miles east of Antelope Creek. The country included between the line thus drawn, the Saskatchewan and the eastern edge of the Côteau, is, with the exception of the plains around Rush and Reed Lakes, generally very hilly, is boulder-strewn and dotted with small lakes. The hills are best developed in the south-eastern part of the area. North towards the Saskatchewan, and west toward Swift Current Creek, they become much flatter. North of the Saskatchewan, a wide, flat plain intervenes between the Côteau and the valley of the river, at the edge of which the hills commence very abruptly, and continue on

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beyond the limits of the map. In this part of the ridge, the hills are steep hills, very steep-sided, and the confused medly of interlacing mounds and ridges which everywhere distinguishes the Côteau country, is particularly well shown. The height of the Côteau east of the south end of Old Wives' Lake, is 2,370 feet, at Secretan it is 2,259, and at the Ver-Height, million Hills, south of the Saskatchewan, it has decreased to 2,230 feet. North of the river it becomes a little higher.

PLAINS NORTH OF THE CYPRESS HILLS.

At the base of the steep escarpment which ends the Cypress Hills Northern slope, on the north, is a broken plain, which falls rapidly towards the north Area. for the first few miles, after which it becomes more level, and stretches away to the Saskatchewan. This great plain, which embraces an area Very diversified surface. of nearly 8,000 square miles, presents an unusually diversified surface. Ridges of high rolling hills, covered with erratics, and extensive areas of bare sand-hills, alternate with broad plains of remarkable fertility, considering the aridity of the climate, and with wide sage-covered clay-flats and every part of it is more or less thickly dotted with lakes, some Lakes. such as Many Island Lake, Crane Lake, and Big Stick Lake, are of large size. The lakes vary through every degree of salinity, from those covered with a thick crust of crystallized salts down to others in which the water is perfectly fresh, and the two extremes are not infrequently met with side by side. At one point, near the west end of Bitter Lake, one of the most saline lakes in the district, a spring of fresh water was found bubbling up on the beach, and the same thing was noticed at several other places. As a rule, however, saline lakes Position of saline lakes. occur more frequently in the low-lying areas, and fresh water lakes on the higher grounds.

Another noteworthy feature of this plain is the utter absence of any Absence of general drainage system. A multitude of small streams, some of which drainage. carry considerable volumes of water during the spring floods, descend into it from the northern slopes of the Cypress Hills, but they are all intercepted at no great distance from their source by lakes where their waters are evaporated, and with the exception of Ross Creek and its tributaries, none succeed in reaching the Saskatchewan. In the central and northern parts, the evaporation is everywhere equal to the precipitation, and no streams of any kind are produced.

Sand-hills, covering more or less extensive areas, are found in every Evaporation. part of this plain. The largest area is known as the Great Sand-hills, and extends with a width of from ten to fifteen miles, from Crane Lake Sand-hills. north about forty miles. At its southern end it sends narrow spurs west to Many Island Lake, and east, with one or two breaks, almost to

Swift Current Creek station. The whole extent of this sandy waste amounts to over 500 square miles. Smaller sandy patches were observed near the mouth of Miry Creek, and also ten miles east from Red Deer Forks, and about six miles south of Sandy Point on the Saskatchewan, and a few scattered hills were found six miles north of Medicine Hat. The other more important sandy tracts occurring within the limits of the district, are the Middle Sand-hills, lying between the Red Deer and Saskatchewan, near their confluence, and the sand-hills found east of the Elbow, on the Qu'Appelle valley.

*Formation
of Sand-hills.*

The areas of drifting sand are due to the action of the prevalent north-westerly winds, on an originally sandy and hilly region. Whenever by any means the protecting covering of matted roots is broken or removed, the dry light sands below, coming under the influence of the eddying currents of air, are carried away and piled up in long oval or rounded banks, across which, clouds of sand are constantly driving, and the process is continued until the main substance of the hill is gone, and nothing but its mere skeleton remains. Occasionally, parts of the hill which have been hardened by infiltrating matter, or rendered more compact by penetrating roots, and are therefore better prepared to resist the erosive force of the wind, remain standing after the softer portions have disappeared. Such fragments frequently assume rectangular shapes, and are usually covered with a shrubby vegetation. The floor from which a hill has been removed, is usually covered with pebbles and rolled bits of bone and lignite which have been sifted out.

*Movement
of Sand-hills.*

All the different areas of sand-hills appear to be progressing slowly towards the east or south-east; the direction of the prevalent winds of the plains. The movement is plainly shown on the eastern side, by the hills being now underlaid by a loamy or clay floor, and on the western side by the solitary sand-hills, which are occasionally met with far in the rear of the advancing mass.

Vegetation.

The sand hills are not entirely destitute of all vegetation, but are occasionally partly covered with grass and shrubs of various kinds. The shrubs most frequently observed, were the choke-cherry (*Prunus Virginianus*) and the wild rose (*Rosa Sayi*). At one point a few miles east of Big Stick Lake, a number of large cotton-wood trees were seen.

Valuable plain.

Between the Great Sand-hills, and the Saskatchewan, is situated a level or slightly undulating plain, which will become very valuable when reached by the settlements. Its soil near the hills is sandy, but towards the river becomes loamy, and in many places is overlaid by several inches of black mould. It is also dotted with a considerable number of small fresh-water lakes. This plain extends west to the mouth of the Red Deer, and includes at least a thousand square miles of excellent agricultural lands. At present it does not contain a single

Extent.

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settler. It is terminated on the east by an escarpment, facing the river and running parallel with it, which has the appearance of having been at one time the shore of a lake, or a former dilatation of the river. The soil on the plain stretching east from the base of the escarpment, consists of the disintegrated upper part of the boulder-clay. It is not very fertile, and supports a scattered growth of long thin grass. The Plain west of Sand-hills.

Good
agricultural
land.
Fine grazing
country.

South of the railway line, the plain lying along the base of the northern slopes of the Cypress Hills, and extending west to the Bull's Head, is unsurpassed for grazing purposes by any part of the Northwest. It is everywhere thickly covered with a heavy growth of nutritious grasses, which, according to Professor Macoun, are almost identical with those occurring in the Bow River country. Good water is found either in lakes or streams in every part of the plain, and ample shelter is afforded by the banks of the net-work of coulees which traverse it in all directions. Small wooded patches occur Fuel. at intervals along the edge of the hills and in the valleys of the principal streams, and a seam of lignite, affording fair fuel, is also found in a number of places. This region, which seems fully equal to the Bow and Belly Rivers district as a stock country, has been ignored in the rush to the latter place, but is now beginning to attract attention.

PRINCIPAL RIVERS AND STREAMS.

The only large river in the district is the south branch of the Saskatchewan, which runs across its northern part. The part of this stream above Medicine Hat has been described in the report for 1882-84. Medicine Hat is situated on a large clay-flat west of the confluence of the united waters of Seven Persons Coulée, Big Plume Creek, and Ross Creek, with the Saskatchewan. At this point, the river changes its previous direction somewhat abruptly, and runs about N. 30° E. as far as the mouth of the Red Deer. In this distance of about one

Fall of stream. hundred miles, the river has a fall of about two feet per mile, and the current in low water runs at the average rate of about two and three-quarter miles an hour.

Tortuous course of stream.

Canyon character of valley.

Depth of valley.

Sand bars.

Disappearance of older rocks.

Character of valley.

For twelve or fifteen miles below Medicine Hat the river follows a rather tortuous course, and makes a number of bends, all of which enclose large clay-flats, usually containing groves of cotton-wood. In the next section, extending as far as Drowning Man's ford, it is much straiter and the bordering flats become very narrow. East of Drowning Man's ford the river enters higher ground, and makes a sudden bend of several miles to the east and south, around which it runs with greatly increased speed, and at the same time, its valley, which hitherto has been somewhat tame, assumes a much more striking aspect. The sloping grassy banks which characterize it farther up, are replaced by high precipitous cliffs of bare grey rock, while it narrows until in many places its breadth of bottom scarcely exceeds the width of the stream. The height of the plateau, above the river, in this part of its course is about 500 feet. The cañon-like character of the valley is maintained for over thirty miles, after which the Cretaceous rocks, by which it has been confined, gradually sink beneath the softer Post-tertiary deposits, and allow the river greater liberty of action. Between the eastern end of the cañon and the mouth of the Red Deer the valley is about a mile and a-half wide, and about 400 feet deep. Its banks, except near the bends of the river, are usually tolerably well grassed, and it contains at intervals a number of wide bottoms, some of which support large groves, principally of cotton-wood. A few miles above the mouth of the Red Deer the channel of the river becomes obstructed with sand bars, and sandy islands are of frequent occurrence.

The great drift-filled depression in the older rocks, in consequence of which they pass below the surface of the river, a few miles west of the mouth of the Red Deer, extends eastward for over seventy miles, and exerts an important influence on both river and valley. The width of both is at once greatly increased, and the channel of the former becomes filled with shifting sand-bars, a feature which characterizes it to a greater or less extent nearly all the way down to the Elbow.

The valley of the Saskatchewan east of the mouth of the Red Deer is for many miles of a very uniform character, and will need only a few words of description. It is usually rather wide, and holds a number of large and valuable bottoms, which, especially in the upper part of this section, are often well wooded. The banks slope easily up to the prairie level, and are grass-covered nearly all the way, scarped banks being of very rare occurrence. At the mouth of the Red Deer the valley is about 400 feet deep, but going eastward this decreases to about 200 feet.

About the valley narrowing fifty feet on the slope of about point the river beneath the Ten miles from the valley suddenly to the east appearance dark Pierre and slips, covered with the surface of the allées while the land-slip smooth coming with crystals covered, and opposite Sycamore three miles Caton. It swinging east. The portion examined by Captain Palliser. "The valley at some distance north, called the valley yards in width of the plain deeper and leaving great deposit. The total measured of the form the river a distributed, shifting sand-

* Exploration

About thirty miles above the mouth of Swift Current Creek the valley narrows in and becomes very shallow, the banks scarcely exceeding fifty feet in height, although from their top there is a further gentle slope of about 150 feet up to the general prairie level, and at the same point the rocks of the Belly River series, which have been so long buried beneath the drift, begin to appear again in the bottom of the valley. ^{Re-appearance of Belly River series.} Ten miles further on the river enters much higher ground, and the valley suddenly increases in depth to about 500 feet. From this point on to the eastern edge of the Côteau, a distance of about fifty miles, the ^{Increased} depth of the valley is exceedingly desolate and forbidding. The dark Pierre shales, which here form its banks, are peculiarly liable to land-slips, and all through this section the sides of the valley are ^{Land slips.} covered with piles of *débris* which have fallen down from above, while the surface is still further confused by the numerous deep branching gullies which score it in all directions. All except the more recent of the land-slips have been worn by the action of the atmosphere into smooth conical hills, the dark bare surfaces of which are often covered with crystals of selenite. A few of the hills are also partially grass-covered, and groves of aspen and cherry are of occasional occurrence. Opposite Swift Current Creek the valley is about 600 feet deep and over three miles wide, and it remains about this size until it leaves the Côteau. Its bottom, which is about a mile wide, is divided up by the swinging course of the river into a series of long narrow flats.

The portion of the river between the Côteau and the Elbow was not examined by me, and I quote the following description of it from Captain Palliser's report.*

"The valley of the Saskatchewan is about $1\frac{3}{4}$ miles in breadth ^{Width of valley.} at some distance above the acute angle which it makes to the north, called the Elbow, but at that place the banks are steeper, and the valley much more narrow . . . The river, averaging 600 yards in width, is depressed at the Elbow, 228 feet below the surface of the plain; but at the base of the Côteau the valley is very much deeper and wider, and the river channel winds through its bottom, leaving great points of dense wood on the left bank, but on the right great deposits of blown sand."

The total distance between the mouth of the Red Deer and the Elbow—measured in three mile stretches—is about 180 miles. The elevation of the former point is 1,934 feet, and of the latter 1,595, which gives the river a slope of 1·9 feet per mile. The fall seems pretty evenly ^{Slope of river.} distributed, and there are very few rapids, but the large number of shifting sand-bars, which block the channel nearly all the way down,

* Exploration of British North America, page 51.

Navigation difficult.

Swift Current Creek.

Deep gorge.

Old Wives' Creek.

Valley wooded.

Former course of stream.

Stream leaves old valley.

will make the navigation of this part of the river, except in high water, a matter of great difficulty. In some places, the river is nearly a mile wide, and splits up into half a dozen different streams, separated by wide bars or sandy islands, through which it is difficult for even a small boat to find a passage.

Swift Current Creek is a small rapid stream about forty feet wide, and from one to two feet deep, and has a total length of about one hundred miles. It rises in the eastern part of the Cypress Hills, from which it obtains most of its waters, and flows in a north-easterly direction for about seventy-five miles, then bending to the north, it empties into the Saskatchewan about sixty miles above the Elbow. In its upper part its valley is about a mile wide, and from two to three hundred feet deep, but nearing the Saskatchewan it has cut a rugged gorge, fully five hundred feet deep into the soft Cretaceous rocks through which it flows. With the exception of a few small groves of poplar, the valley of this stream is almost treeless until within a few miles of the Saskatchewan.

Old Wives' Creek occupies a neutral position midway between the basins of the Saskatchewan and the Missouri. It empties into Old Wives' Lake,—a large lake without any present outlet. This stream has three main branches. The northern and middle ones rise in the Swift Current Creek plateau, the southern in the Wood Mountain plateau. The three branches, after uniting, form a stream twenty feet wide, and about a foot deep, and this represents the drainage of a region nearly five thousand square miles in area. The numerous secondary branches of this stream have cut deep gashes in the plateau where they take their rise, but after they become united farther out on the plains, their valleys are usually very wide and shallow. The valley of the middle branch is wooded at several points on its lower part. After uniting with the south branch it is covered for several miles with a thick forest, principally composed of the ash-leaved maple (*Aegopodium aceroides*). Old Wives' Creek, or its southern branch at least, may at one time have flowed eastward through the large and at present almost unused valley, connecting it with Twelve-mile Lake, and then through Big Muddy Creek to the Missouri, although to do so would necessitate a considerable change in the present relative elevation of the country.

The middle branch exhibits at one point a good example of a stream diverted for some distance from its pre-glacial channel. As is usual in such cases, while the abandoned valley is wide and shallow, and evidently partially filled with drift deposits, the more recent one is narrow and gorge-like, and affords good sections of the rocks of the country. The change in the course of the stream has been effected either by obstructions in its channel, during the glacial age, or by a gradual elevation of the country to the south.

The White Hills east of the town of Fort Macleod flows eastward from the town, and continues on to the town of Wood Mountain, crosses the valley of the Bow River after a course of about ten miles. The hills are peculiar features of the landscape, rising through the valley, often in short, steep, rocky ridges, often miles wide, and appearing like scarped bank coulees, with various streams.

Among the streams to be noticed which flow into the Bow River are Piney Creek, and the Rocky Creek.

The lakes of the district, it is believed, are all of glacial origin.

(1) Lakes of the headwaters.

(2) Lakes of the receptacle.

(3) Lakes of the lake.

The lakes of the headwaters are large. Two of them, Lake Louise and Lake Minnewanka, are about four miles long and one mile wide, and closely approach the town of Banff. They both lie in the headwaters of the Bow River, and are situated in the valley of the Bow River, about four miles from the town of Banff.

The White Mud River drains all the southern part of the Cypress Hills east of the Gap. It is the outlet of Cypress Lake, from which it flows eastward, cutting off in its course a portion of the Cypress Hills from the main plateau, and then bending more to the south, it continues on through the White Mud River plateau, to the eastern end of Wood Mountain, from which point it turns still more south, and crosses the boundary about twelve miles east of the 107th meridian, after a course on Canadian territory of about one hundred and thirty miles. Where it crosses the boundary it is about fifty feet wide. A peculiar feature of this stream is the way it has disregarded the low lands to the south and north in selecting a channel, and has chosen one through the higher plateau country, through which it has carved a valley, often upwards of five hundred feet deep, and from three to four miles wide. The valley is comparable in size with that of the Saskatchewan where it breaks through the Côteau, and is even more desolate in appearance, owing to the absence of all arboreal vegetation. Its ^{Strange course of stream.} ^{Character of valley.} scarped banks are rugged and broken, and seamed with innumerable coulees, which afford a complete and almost continuous section of the various strata into which they cut.

Among the less important streams and valleys of the district may be noticed Battle Creek, Four-mile, and Medicine Lodge Coulées, all of which flow from the Cypress Hills southward to Milk River, and Big Plume Creek, and Ross Creek, which drain northward to the Saskatchewan. In Wood Mountain the Missouri system is represented by Little Rocky Creek and Poplar River.

LAKES.

The lakes are not confined to any particular locality or formation in the district, but are scattered more or less thickly over every part of it. They may be roughly divided into three classes—

(1) Lakes occupying portions of the abandoned channels of ancient streams. ^{Classification of lakes.}

2) Lakes occupying depressions in the drift which have become the receptacle for the drainage of the adjoining higher land.

3) Lakes partaking of the character of springs.

The lakes of the first class are few in number, but are usually rather large. Twelve-mile Lake will serve as a good example. This lake is ^{Twelve-mile lake.} about fourteen miles long, but its width seldom exceeds a mile, and it is closely hemmed in nearly all round by high scarped banks. It occupies part of a large valley which is continuous from Old Wives' Lake ^{Valley continuation to the Missouri.} to the Missouri. A stream which enters this valley about a mile east of the lake, instead of flowing into the lake turns eastward, and

Elevation of
water-shed.

Cypress Lake.

Old Wives' Lake

Lakes of the
third class.

eventually under the name of Big Muddy Creek, flows into the Missouri. The water-shed between the lake and this stream, in the valley, is 285 feet above Old Wives' Lake, and 211 feet above the mouth of the Big Muddy, thus if this valley ever carried water between Old Wives' Lakes and the Missouri, its present watershed must have since been elevated about 350 feet. The outlet and principal inlet of Twelve-mile Lake are both situated near its western end, and serve to keep that part of the lake comparatively fresh, but going east its water gradually becomes more saline, and near the eastern end the shore in some places is covered with salts which have crystallized out.

Another example of lakes of this class is afforded by Cypress Lake which occupies a great valley connecting the East Fork of Milk River with the White Mud River. Cypress Lake is about ten miles long and has a maximum width of about three miles. It is fed by streams issuing from the Cypress Hills, and its water is always clear and fresh. Near the eastern end of the expanded part of the lake there is a small island with high rocky banks, which has the reputation among the Indians of being haunted.

The lakes of the two latter classes, are, in many cases, so similar in appearance that it often becomes impossible to separate them, and very frequently a lake owes its existence to the combination of both causes. The majority of the lakes in the Côteau and in other similar areas of high rolling country, seem to belong to the third class. A few lakes in the second class are fed by streams, amongst which is Old Wives' Lake, the largest lake in the district. This lake is divided into two parts, each of which is about twenty miles long. The two divisions are united by a sluggish stream, about ten miles in length, into which Old Wives' Creek empties. The greater part of the lake lies in the Côteau belt, in which it occupies a depression about one hundred feet deep. The water of Old Wives' Lake is somewhat saline, but not so much so as to be unfit for use. Amongst the other lakes of the second class I may mention Many Island Lake, Big Stick Lake, and Crane Lake, three shallow saline lakes, each covering about thirty square miles, and fed by intermittent streams from the Cypress Hills. The lakes of the third class are usually very small; they occur in great profusion in the Côteau and other similar high rolling ridges, and are seldom long absent from any part of the district.

EL E V A T I O N A B O V E S E A - L E V E L O F T H E P R I N C I P A L L A K E S .

Old Wives' Lake.....	2,165 feet
Many Island Lake.....	2,280 "
Big Stick Lake.....	2,254 "

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Crane Lake.....	2,420	feet.
Cypress Lake.....	3,240	"
Twelve-mile Lake.....	2,455	"
Devil's Lake.....	1,887	"
Wild Horse Lake.....	2,828	"
Elk Water Lake	4,020	"
Antelope Lake.....	2,304	"
Rush Lake	2,269	"
Hay Lake (Cypress Hills)	3,730	"

DESCRIPTIVE GEOLOGY.

THE CYPRESS HILLS AND VICINITY.

The Cypress Hills plateau is simply an outlier of the Wood Mountain, Côteau, and Souris River Laramie* area, which has escaped destruction on account of the thick deposits of Miocene conglomerates which everywhere cover it. The rocks observed in it are referable to the following series:—

Miocene.
Laramie.
Fox Hill.
Pierre.

The Pierre shales, the Fox Hill sandstones, and the Laramie, here as elsewhere, are strictly conformable, and have a general north-easterly dip of about ten feet to the mile. The Miocene is laid unconformably on the Laramie, on which it usually rests, but in some places it overlaps and comes in contact with the Fox Hill.

The west end of the Cypress Hills, forms a geological centre around which the formations mentioned above sweep in roughly concentric zones. I will define the boundaries of these formations in a general manner only, as they are all extremely irregular, and can be best seen from the map which accompanies this report. The outer boundary of the Pierre shales, which forms the basal member of the Cypress Hills system, extends in a somewhat sinuous line from the Bull's Head plateau to the head-waters of Sage Creek, and then continues on to, and crosses the 49th parallel, a few miles west of the

Cypress Hills plateau.

Boundaries.

* Throughout this report the name Laramie is used to designate the important series of deposits which follow the Fox Hill or "Cretaceous No. 5," in ascending order. The beds in Wood Mountain, also here referred to by this name, are an extension of those of the Souris River region which are the representatives of the typical Fort Union series of the Missouri. There is, however, every reason to believe that these and the farther western beds to which the name Laramie was first applied are equivalent in age.

fourth principal meridian. From the Bull's Head the same boundary also runs in a north-easterly direction to Irvine station, and then on to the South Saskatchewan, which it crosses about thirty miles west of Swift Current Creek. Between Irvine and the Saskatchewan, the rocks are entirely concealed by the drift, and the boundary is therefore somewhat uncertain. The boundary line just indicated, besides separating the Pierre from the Belly River series, also divides the district into two distinct parts, which differ from one another very materially in many respects, but more especially in regard to the distribution of the plateaus, all of which occur in the eastern part. The inner boundary of the Pierre shales is three or four miles distant from the base of the plateau near its western end, but in going eastward it gradually approaches and at length becomes coterminous with it. Still further eastward, owing to the decreased height of the country and in spite of the light easterly dip of the beds, the Pierre shales rise in the escarpments till they at length form nearly the entire substance of the plateau.

Pierre shales.

Sections on
Willow Creek.

Sections along
northern slope.

Large nodules.

The Pierre shales are well exposed all around the Cypress Hills, which they underlie throughout, and the dark clay banks which denote their presence can be seen in nearly every coulée leading from the plateau. In the valley of Willow Creek, a few miles south of the "Head of the mountain," they are particularly well shown. At this point the valley is a couple of miles wide, and its long gently-sloping banks, which are formed entirely of Pierre, are scarped from top to bottom, and are worn into a succession of rounded hills, which are slowly wasting away. The surfaces of these hills are covered in some places with fragments of calcarious nodules, which have crumbled to pieces and which often contain *Ammonites* and *Baculites*, and occasionally a few vertebrate remains. The valleys of Battle Creek, Four-mile Coulée, and the White Mud River, are cut down through the Laramie and Fox Hill into the Pierre, and afford good exposures of the shales at many points. Along the northern slope, the best sections are found south of Sidewood station, where several hundred feet of the shales is exposed in the banks of the numerous small streams which cut back into the plateau. Good sections are also found in the upper part of the valleys of Fish, MacKay, Big Plume, and Ross Creeks. In the valley of the latter creek the shales contain numerous nodules, which yield unusually good specimens of the ordinary Pierre fossils. A few miles west of the "Head of the mountain," at Bull's Head plateau, the lower part of the Pierre is well exposed, and is seen resting on the light colored beds of the Belly River series. The same thing was also observed on Big Plume Creek, Ross Creek, and further south, on the upper part of Sage Creek. The surface of the Bull's Head plateau section of the

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shales are encumbered with gigantic calcareous nodules, some of which are from ten to fifteen feet in diameter. These nodules are usually roughly spherical in shape, and become yellowish on weathering. Some of them are fossiliferous, and the following species were obtained there:—*Callista Deweyanum*, *Protocardium subquadratum*, *Liopista quadrata*, *Pteria lingueformis*, *Gervilia recta*.

Nodules somewhat similar to those at Bull's Head plateau were also found in an exposure of Pierre a couple of miles north-east of Irvine.

In the Cypress Hills region the Pierre shales are about 800 feet thick, and for the greater part consist as elsewhere of dark clay shales. The chocolate-colored sandy shales which form the upper part of the formation on the Red Deer and Belly Rivers, are replaced in this district by thick beds of greyish and yellowish sandstones. These sandstones, which are seldom persistent for any distance, are well shown on Battle Creek, and in the "Gap." The coal-bearing zone which occurs near the base of the shales farther west, is also found on Sage Creek, Ross Creek, and in all places where the base of the formation is exposed, though with greatly diminished importance. In the eastern part of the district the presence of this zone cannot be ascertained without boring, as the upper part of the formation only is exposed.

The Pierre is succeeded in ascending order by the Fox Hill sandstones. This formation is composed mainly of yellowish indurated sands and sandstones, and has a maximum thickness in the hills of about 150 feet. In some places the whole section is composed entirely of ferruginous sandstones, and the transition from the underlying argillaceous beds is very abrupt, but in most cases the lower part of the formation consists of alternating bands of sandstone and shale, and no distinct line can be drawn separating it from the Pierre, the upper part of which is always more or less arenaceous. The Fox Hill though never wholly absent, becomes in some places very thin, and as it is very closely connected with the Pierre, of which it simply forms an upper part, and is of no economic importance, no attempt has been made to represent it separately on the map.

The Fox Hill is well exposed in many places both north and south of the hills. Very characteristic exposures occur on a tributary of Willow Creek, a few miles south of the "Head of the mountain," where the following section was observed:—

	FEET.
1 Greyish sands	20
2 Dark clays	40
3 Greyish and yellowish sandstone	30
4 Dark clays	30
5 Dark rusty and light yellowish coarse soft sandstone	130
6 Dark shales (Pierre)	—

Sand-hills.

The upper part of this section is probably Laramie. The thick band of yellowish sandstone near the base of the section is very soft, and near the edge of the coulée, where it is unprotected, it has been disintegrated and blown into sand-hills. Good sections also occur on Battle Creek, in the "Gap," and at many points along the White Mud River. A few miles east of East End Coulée the Fox Hill appears from beneath the Laramie, and then forms the surface of the hills nearly all the way to Swift Current Creek. It is also found south of the hills in Old-man-on-his-back plateau, which is capped with about 150 feet of ferruginous sandstones. In the plains north of the Cypress Hills and west of the Côteau, the Fox Hill has entirely disappeared, and the greater part of the material of the sand-hills now existing there has no doubt been derived from it.

Laramie.

Junction of
Laramie and
Fox Hill.

The Fox Hill is overlaid conformably by the Laramie, a formation whose precise position in the geological scale has been a matter of much dispute, but which is now pretty generally regarded as a transitional one between the Cretaceous, properly so called, and the Tertiary. The junction between the Laramie and the Fox Hill is marked by no sudden lithological break, and it is often difficult to determine the exact point at which one is replaced by the other. I have usually drawn the line of separation near the base of a thick band of greyish sandstone, which seems to mark nearly everywhere in this district, the base of the Laramie. This sandstone differs from the Fox Hill sandstone in colour, and also in the absence of clay-ironstone nodules containing *Ammonites* and *Baculites*, which is so persistent and typical a feature of the latter.

Thickness

The portion of the Laramie represented near the west end of the Cypress Hills has a thickness of about 800 feet, but this gradually decreases eastward, and also becomes very irregular, owing to the unequal effects of denudation at different places both before and since the deposition of the Miocene. In some places, as in the "Gap," and also at the East-end Coulée, it has been entirely swept away, and the tower formations uncovered.

Best exposures.

The best exposures of the Laramie occur along the valley of the White Mud River, between Cypress Lake and East-end Coulée. This valley is in some places fully 600 feet deep, and its banks, which are always more or less scarped, afford very complete sections of all the formations found in the hills. The following somewhat detailed section was obtained a short distance above the trail-crossing of the White Mud River near East-end Coulée. It is in descending order, and commences about fifty feet from the top of the bank, the upper part of which is grass-covered.—

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	FEET.
1. Greyish and yellowish sands and clays, sands very fine grained, color predominantly yellow	50
2. Greyish and yellowish clays	15
3. Carbonaceous shales.....	5
4. Soft yellowish indurated sands showing false bedding..	30
5. Dark carbonaceous shales	4
6. Yellowish and greyish, soft, and somewhat arenaceous clays.....	6
7. Yellowish clays, sands, and sandy clays	30
8. Carbonaceous shales, containing a small seam of inferior lignite.....	6
9. Yellowish arenaceous clays	20
10. Carbonaceous shale	2
11. Yellowish and greyish sandy clays or silt.....	10
12. Light brownish and greyish clays	15
13. Yellowish and greyish sandy clays containing some ironstone.....	10
14. Carbonaceous shales and impure lignites	4
15. Yellowish and greyish sands, clays, and sandy clays..	30
16. Carbonaceous shales containing a small seam of inferior lignite.....	6
17. Dark clays.....	30
18. Greyish clays	4
19. Very light grey, slightly undulated sands	20
20. Carbonaceous shales	1
21. Very light grey, slightly indurated sands.....	15
Total Laramie.....	313
22. Yellowish sands containing some beds of hard sandstone and a number of ironstone nodules	
Fox Hill.....	120
23. Greyish and dark clays	
Pierre.....	78
Total thickness of section.....	508

The upper part of this section has a general yellowish colour, viewed from a distance, but on closer inspection it is found to contain a number of small grey and dark beds, and is composed almost entirely of sands and pure and arenaceous clays. Small beds of carbonaceous shale occur throughout the section, and often contain thin lignite seams. There is a marked absence of hard sandstones in the exposures at this point, but on the other side of the valley a little farther up the stream, a thick bed of hard sulphur-yellow and mostly falsely bedded sandstone forms the upper part of the Laramie, and in other places similar nodular non-persistent beds occur occasionally in different parts of the section. Below this series of sands, clays and silts, and forming the White band, lower part of the Laramie, there is nearly always found a band of

Appearance of sections.

Absence of hard sandstones.

clays and sands, which in many places has been bleached almost pure white by the action of the vegetable debris now represented by carbonaceous matter. This band, though only from twenty to fifty feet thick, forms, owing to its color, a very conspicuous feature of the section, and can be seen for miles up and down the valley. Exposures of it, in the distance, look like great snow-banks. The clays and sands in it, like those above, graduate almost imperceptibly one into the other, and seldom remain pure for any distance. They are usually associated with small beds of carbonaceous shale and lignite. This grey band has a very wide distribution, as it is found in the White Mud River plateau, in the Laramie area south of the east end of the Cypress Hills, in Wood Mountain, and also in the Côteau north of the South Saskatchewan. Very fine exposures of Laramie also occur a few miles farther up the valley of the White Mud River near the mouth of Fairwell Creek, where the following general section was measured:—

Distribution of
white band.

	FEET.
1. Yellowish very fine-grained arenaceous clays, passing into pure clays and sands.....	110
2. Greyish clays, carbonaceous shales, and thin beds of lignite, yellowish sands, clays, and sandy clays	120
3. Greyish shales	6
4. Carbonaceous shales	4
5. <i>Lignite</i>	3
6. Greyish shales.....	30
7. Brown carbonaceous shales	6
8. Grey and almost pure white sands and clays	50
9. Coarse rusty yellow sands (Fox Hill).....	125
10. Lead-grey and dark shales (Pierre)	50
	<hr/> 504

General com-
positions of
Laramie.

Exposures.

The two upper divisions of this section, though very similar lithologically, appear quite distinct when seen from a distance owing to the difference in colour, the lower one having a general greyish colour, while in the upper yellowish tints predominate. The general composition of the Laramie, as developed in the south-eastern part of the hills, may be briefly described as consisting of a lower light-grey band of sandstones and clays, underlying a carbonaceous zone, which usually includes a lignite bed from two to three feet thick, and is overlaid by a series of sands and pure and arenaceous clays. The coarser varieties of the sandstone in this series are usually affected by false bedding.

The Laramie appears at intervals along the southern part of the eastern escarpment of the hills, and at one place was observed to include a thick bed of grey sandstone which weathers into monumental forms; but going farther north, it thins out rapidly, and near the

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north-east corner disappears, and the Miocene and Fox Hill come into direct contact. The following section will explain the arrangement of the beds in this part of the hills:—

	FEET.
1. Pebble conglomerate	30
2. Coarse soft yellowish sandstone	60
3. Clays, looking dark in bank, but yellowish and greyish on fresh exposure.....	80
4. Yellowish sandstone containing ironstone nodules.....	50
	<hr/> 220

The northern escarpment of the Cypress Hills between East-end Coulée and the "Gap" is grass-covered, and affords no exposures of any importance. West of the "Gap," the Laramie is seen at several points in the northern slope of the hills, and also in the banks of the valleys of Four-mile Coulée and Battle Creek, but all the exposures are very inconsiderable. The best one occurs a couple of miles west of Elk-water Lake, at which point an extensive land-slide, or a series of slides, has uncovered the face of the escarpment. The section here, in descending order, consists of a bed of pebble conglomerate, about fifty feet thick, beneath which is a rather hard bed of sandstone, from three to four feet thick, which weathers to a dull reddish color, and shows false bedding. It is underlaid by softer greyish and yellowish sands, and these by bluish clays. The strata brought down by the slide include clay beds of different shades of red, yellow, and bluish-green. The rocks exhibited in this section are higher in the Laramie than any seen elsewhere in the hills.

Section near
Elk-water Lake

In the upper part of the valley of Battle Creek the following section was obtained. It occurs near the base of the Laramie, and is given in descending order:—

	FEET.
1. Bluish clays.....	20
2. Yellow sands.....	50
3. Carbonaceous shales.....	2
4. Greenish and bluish clays.....	40
5. Yellowish and greyish sands.....	30
	<hr/> 142

This section, which is on nearly the same horizon as the white beds on the White Mud River, together with a few other smaller ones, found at different places west of Battle Creek, seem to show that the divisions of the Laramie, as exhibited in the south-eastern part of the hills, are not applicable here, and also that the beds of fine sandy clays or silts, which occupy such a large proportion of the section there, are replaced in this part by beds of pure clay and indurated sand.

Carbonaceous zone.

The carbonaceous horizon, which exists nearly everywhere near the base of the Laramie, is found all round the western end of the hills, and contains in several places a workable seam of lignite. This seam has been burnt in many places around the north-west corner of the hills, and can be traced from point to point by the zone of reddened rocks thus produced. It is found near the northern end of Elk-water Lake, where it occupies a position about half way down the bank, and has a thickness of about three feet, and it is also exposed in nearly all the larger coulées leaving the western end of the hills. The following section around it was obtained on a tributary of Willow Creek, a few miles south-east from the "Head of the mountain."

	FEET. INCHES.
1. Dark clays	— —
2. Yellowish sandstone.....	40 —
3. Carbonaceous shale.....	6 —
4. <i>Lignite</i>	2 6
5. Carbonaceous shale.....	5 —
6. <i>Lignite</i>	4 —
7. Carbonaceous shale.....	3 —
8. <i>Lignite</i>	1 6
9. Carbonaceous shale.....	2 —
10. Grey soft sandstone.....	4 —
11. Carbonaceous shale.....	2 3
12. Grey sandstone.....	2 3
13. Carbonaceous shale.....	4 —
14. Soft, grey, massive sandstone.....	15 —
	91 3

Fossil.

The same seam, or one occupying approximately the same horizon, was also observed in several places along the White Mud River, in the south-eastern part of the hills, but in none of these exposures it is over three feet thick, and its quality here is usually inferior.

Miocene.

With the exception of fragments of silicified wood, which are very plentiful in a number of places, no fossils of any kind were found in the Laramie deposits of the Cypress Hills.

The Laramie seems to have been elevated, and to have suffered extensively from denudation before the deposition of the Miocene, which, as already stated, overlies it unconformably, and which forms the surface in all the higher parts of the Cypress Hills, and covers an area of upwards of 800 square miles. The Miocene has been removed from the lower part of the plateau included between Battle Creek and Four-mile Coulée, from the "Gap," and from the depression running across the hills north of the east end of Cypress Lake, and has also been cut through by all the larger coulées. West of the "Gap," this formation consists of a uniform sheet of hard conglomerate, about 50 feet thick, which is well exposed

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in many places in the valleys of Battle Creek, Four-mile Coulée, and along the edges of the plateau. In the eastern part of the hills the conglomerate is usually associated with beds of sandstone, sands, clays and marls, and the thickness of the whole deposit increases to about 500 feet.

The conglomerate which forms such a marked feature of the Miocene Conglomerate, 300 feet, is usually composed of quartzite pebbles cemented together by carbonate of lime, but also appears under a number of other forms. In some places the pebbles lie loosely in a matrix of coarse yellowish sand, and in others they are consolidated by a ferruginous cement. Beds several feet thick also occasionally occur, which contain nothing but loose pebbles. The conglomerate sometimes contains interstratified beds of coarse sands, into which the pebbles seem to grade, and also beds of white, or cream-coloured clays and sands, which occasionally hold calcareous nodules, some of which when broken across were found to be spotted by small black concretionary grains of oxide of manganese. The pebbles of the conglomerate are nearly always composed of hard quartzite, and vary in size from coarse sand to eight and nine inches in diameter, though the usual size is from two to four inches. They are usually white on a fresh fracture, but grey and flesh-coloured tints are also common. They are sometimes found forming the lower surface of hard sandstone beds, or scattered more or less sparingly through them. Beds of pebble conglomerate, though more frequent and larger near the base of the Miocene, are found at irregular intervals all through it, and are of all thicknesses, from a single layer of pebbles up to beds fully fifty feet thick. In many cases the formation consists of a single thick bed of this rock. Besides the pebble conglomerate, beds composed of angular pieces of clays enclosed in a matrix of hard sandstone, and forming a species of breccia, are occasionally found.

Pebbles of conglomerate

The sands of the Miocene sometimes form hard beds, from one to two feet thick, but are usually only slightly indurated, and are nearly always affected by false bedding. In one place, near the eastern escarpment, a bed was observed which consists of hard, clean, angular, siliceous grains, nearly all of uniform size, and apparently quite loose and unstratified. This bed contained a few pebbles and rolled fragments of fossilized wood and bones.

Small beds of impure carbonate of lime, or marl, are also occasionally found amongst the deposits of this formation, and are worth mentioning, as they may become of some economic importance, on account of the scarcity of limestone on the plains. They are usually white or light-yellowish in colour, are seldom very hard, and are filled with small nodules, composed of varying proportions of sand and calcite. They

seem to underlie the surface over a great part of the hills, a fact shown by the material brought up by burrowing animals, when other exposures are wanting.

Sections of
Miocene.

Good sections of Miocene rocks occur in the eastern part of the hills in the banks of the valleys of Fairwell Creek, the White Mud River and along the eastern escarpment. In the valley of the White Mud, beds of pebble conglomerate, occasionally associated with some whitish marls or yellowish sands, the whole measuring fifty or sixty feet, crop out near the surface at intervals all the way between Cypress Lake and the mouth of Fairwell Coulée. East of Fairwell Coulée, the deposit becomes much thicker, and the conglomerate is overlaid by about a hundred feet of dark greyish clays and sands. A very good exposure, about 150 feet thick, is found in the eastern escarpment, a short distance south of East-end Post. At this point, the lowest bed consists of hard, greyish sandstones holding some pebbles, and also some angular fragments of hard, greyish clay. This bed is overlaid by coarse, brownish-red sands, and the sands by reddish, greyish, and dark clays, interstratified with some beds of loose pebbles. In the north-eastern end of the hills, the upper part of the formation has been swept away, and scarcely anything except a single thick bed of conglomerate remains.

Best exposures.

The best exposures of Miocene are found in the banks of a large coulée, which crosses the hills a few miles west of the eastern escarpment. This coulée contains Fairwell Creek, which flows south into the White Mud River, and also a stream flowing north into Swift Current Creek. These two streams, near the central part of the plateau, split up into a great number of branches, which ramify in all directions, and cut deeply into the soft Miocene deposits, which here attain their greatest development. Numerous exposures occur on both the main coulée and its branches, but they are nearly always small and fragmentary, and nowhere could anything approaching a complete section be obtained. The rocks exhibited in these sections consist of pebble and clay conglomerate with occasional beds of loose pebbles, hard and soft sandstones, the latter usually very coarse-grained and affected with false bedding, clays of various colors, but usually dark grey, and small beds of impure limestones and whitish marls. The total thickness of the whole deposit at this place is about 500 feet, but going west, it thins out rapidly, and in a few miles everything but the pebble conglomerate disappears.

Thickness.

Mammalian
remains.

A number of interesting mammalian remains were found in these beds while examining them in 1883, and since then, Mr. T. C. Weston has made a much larger collection, and the whole has been placed in the hands of Professor Cope for examination. The only invertebrate fossils found were some casts of *Unio* shells.

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F. C. Weston, Photo June 1, 1891.

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In a couple of places south of the "Gap," along the valley which connects Cypress Lake with the East Fork of Milk River, some small arenas of conglomerate were found, which are probably of the same age as the incoherent gravels and conglomerates found in so many places, beneath the drift, in the valleys of the larger streams (compare Report of Progress, 1882-84, p. 140, c.).

SWIFT CURRENT CREEK PLATEAU.

Swift Current Creek plateau is a low diffuse ridge, situated north-east from that of the Cypress Hills and separated from it by a shallow depression about twelve miles wide. It is about forty-five miles long and twenty wide, and has an elevation of four to five hundred feet above the plains around it, or 2,130 feet above the sea. Its surface is usually undulating, but in some places becomes very hilly, and its edges show comparatively easy slopes, and nowhere present the abrupt escarpments so characteristic of Wood Mountain and the Cypress Hills. It is drained on the north by Swift Current Creek, which runs through the plateau for some miles, and on the south by the different branches of Old Wives Creek. A deep valley has been cut completely across it, by a branch of the former stream incising it with one from the latter.

The easy slopes of this plateau, the grass-covered condition of most of its valleys, and the consequent absence of any extensive exposures, renders the collection of details in regard to its geological structure a task of some difficulty. Its main features, however, are simple and easily understood. Two formations only enter into its composition, *viz.* the upper part of the Pierre shales and a deposit similar in composition to the Miocene rocks of the Cypress Hills. The latter formation, which is referred to the Miocene, rests unconformably on the Pierre; the Fox Hill and Laramie being usually absent. This plateau suffered more severely from the effects of denudation previous to the deposition of the Miocene than the Cypress Hills, as not only have the Fox Hill and Laramie been almost entirely swept away, but part of the Pierre also has disappeared.

The Pierre shales, in the north-eastern part of this plateau, present Pierre shales, a somewhat strange appearance to one accustomed to their dark tints elsewhere, as here at a distance they look almost white. The lightness of the color, is, however, partly due to bleaching, as in a fresh exposure, light-grey and bluish tints prevail. The difference in color, is accompanied by a corresponding change in composition, as they have become more arenaceous, and in places pass into a soft sandstone. The foliation is also unusually coarse, and the different beds often exhibit slight differences in color due to their more or less arenaceous

Newer con-globularites.
Swift Current Creek plateau.

Composition.

Change in color
and compo-sition.

character. The faces of some of the sections are studded with large arenaceous nodules, which are frequently incrusted with radiating crystals of selenite. Shales answering to the above description are exposed in a number of sections along Rush Lake Creek, and some of its branches, and are there usually overlaid by a heavy bed of conglomerate.

Shales darker. A few miles farther west, on Swift Current Creek, where the shales are next met with, they are darker in color, but are still very arenaceous, and it is possible that some of the upper beds may represent part of the Fox Hill.

Exposures of shales.

The Pierre shales, with the exception of a short interruption after the stream enters the plateau country, are exposed along the whole length of Swift Current Creek, from the Cypress Hills to the Saskatchewan, the fall of the stream being almost identical with the dip of the formation. They are also exposed in a number of places along the southern and eastern edges of the plateau, in the valleys of the different branches of Old Wives Creek. One of the exposures near the south-eastern edge of the plateau in Township 10, Range xi., west of the 4th Principal Meridian, yielded a number of fossils, amongst which are:—*Yoldia Evansi*, *Lucina occidentalis*, *Neara Moreanensis*, *Acteon attenuatus*, *Anisomyon centrale*, *Anchura Americana*, *Scaphites Nicolleti*, *Schaphites Subglobosus*.

Pierre overlaid by Miocene. The Pierre shales are usually overlaid unconformably by the Miocene. At one point near the north-eastern edge of the plateau an exposure of yellowish and greyish sands and silts, and greyish and dark clays was observed, which may possibly belong to the Laramie, and coarse yellowish sandstones, resembling the Fox Hill, were seen in a couple of places; but in most cases, these formations are absent, and the Miocene rests directly on the dark argillaceous clays of the Pierre.

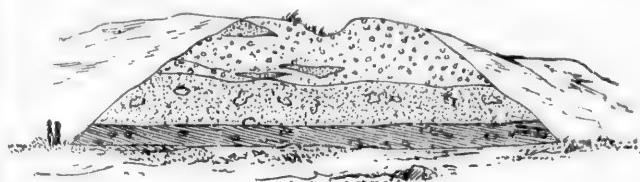
Miocene. The Miocene deposits of Swift Current Creek's plateau, while resembling in a general way, the corresponding rocks in the Cypress Hills, differ from them in containing a smaller proportion of pebble conglomerate, and in the superior hardness of some of the sandstone beds. The best exposures are found in the valley, noted previously as crossing the plateau transversely, the banks of which afford a broken section of about 300 feet. This section was too fragmentary to admit of any detailed measurements, but the rocks exhibited in it may be generally described as consisting of coarse false-bedded sandstone, with occasional beds of a harder finer-grained variety, usually greyish or light-yellowish in color, hard silicious sands, clays, shaly clays, marls and pebble conglomerates. The conglomerate usually forms a compact rock, the pebble being held together by a hard, calcareous cement, but in some places its constituents are very feebly consolidated, and occasionally

Best exposures.

Conglomerate.

they lie quite loose in the bed. The pebbles, which are always well-rounded, are formed of hard, light-coloured quartzites, and are probably like those of the Cypress Hills, derived from the Cambrian quartzites of the Rocky Mountains. In addition to the rocks mentioned above, beds of impure nodular limestone are of occasional occurrence. These beds, which are very characteristic of the Miocene, are only slightly indurated, and when subjected to the influence of the atmosphere, soon crumble away and cover the bank with small nodules, ranging in size up to about half an inch in diameter. The general section presents a somewhat greyish appearance at a distance, owing to the obtrusive whiteness of some of these calcareous beds, although most of them are found to be more or less yellowish on closer inspection. The conglomerates in this section, are not developed to nearly the same extent as in the corresponding sections in the Cypress Hills, a fact due, no doubt, to their greater distance from the mountains, but toward the outskirts of the deposit they become relatively much more important, and occasionally the whole formation is reduced to a single thick bed of this rock.

The Miocene sections on Swift Current Creek begin a few miles above the crossing of the Canadian Pacific railway with a single bed of conglomerate. Farther up, this bed becomes associated with irregular deposits of silts, sands and clays, which disappear again as the western boundary of the formation is approached. The sections on this stream are sufficiently well exposed to show that there is a small but well-defined dip towards the centre of the area, and that the Miocene occupies a shallow basin-shaped depression in the Pierre. This fact, taken in connection with the general irregular character of the deposits, the prevalence of false bedding, and the decreasing proportion of conglomerates towards the centre, show the formation to be of lacustrine origin, and it was probably deposited in a dilatation of some large river flowing eastward from the Rocky Mountains.



SECTION SHOWING MIOCENE BEDS SUPERPOSED ON PIERRE SHALES.

The exposures along the southern and eastern edges of the plateau are insignificant in extent, but are sufficient to define the boundary of the formation in a general way. One of these, which shows the junction of the Pierre and Miocene very well, is illustrated in the accompanying cut. It consists of fifteen feet of bluish, yellow-

weathering, fine-grained argillaceous sands holding calcareous nodules, resting on the Pierre and underlying about fifteen feet of pebble conglomerate. In this section, small beds of sand are enclosed in the conglomerate.

Bed of conglomerate.

On Rush Lake Creek, the Pierre is overlaid by a single thick bed of conglomerate, the extent and relations of which could not be very well worked out, owing to the infrequency of exposures, but which probably post-dates the Miocene in age.

Fossils.

The only fossils which I succeeded in finding in the Miocene of this plateau were a few indeterminable fragments of the remains of vertebrate animals. Invertebrate fossils seem to be entirely absent.

Drift.

There are a few Laurentian boulders scattered over Swift Current Creek plateau, but otherwise, except on its northern boundary, it is entirely driftless. This fact is of some importance in tracing out the Miocene, as its junction with the Pierre can be defined approximately by noticing the difference in the materials brought up by burrowing animals; the light-colored calcareous débris brought up by animals burrowing into the Miocene being different from that seen when the surface is underlaid by Pierre or boulder-clay.

GEOLOGY OF THE COUNTRY SOUTH OF THE CYPRESS HILLS.

The rocks underlying the surface of the country in the south-western corner of the map are well exposed in the almost precipitous and scarped banks of the valley of Milk River, and also a little farther north in the valley of Many Berries Creek, the outlet of Lake Pakow-ki. These two streams occupy valleys from 200 to 300 feet in depth, and from a mile to a mile and a half in width, the banks of which afford magnificent sections of the rocks belonging to the Belly River series, into which formation they are cut.

Milk River valley was visited and examined by Dr. G. M. Dawson in 1874, while connected with H.M. North American Boundary Commission Survey, and the following detailed description is quoted from him:—*

Milk River valley.

"The valley of the Milk River is one of the most important features met with on the line of the forty-ninth parallel, and offers continuous and magnificent sections of beds referable to the Lignite Tertiary series. The country on both sides of it, is seamed with tributary ravines and gorges, the banks of which are often nearly perpendicular, and which ramify in all directions. Where the Line crosses the river

* Geology and Resources of the Forty-ninth Parallel, 1875, p. 117. The quotation is given at length, as the volume is now out of print. The beds described were at the time supposed to be of "Lignite Tertiary" (Laramie) age. See Report of Progress, 1882-84, pp. 45 C-122 C.

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valley, it is utterly impassable for waggons or carts, and near this place the Great Dry Coulée branches off, which, according to Palliser's map, runs to Lake Pā-kow-ki. The appearance of the valley of the river itself is strange and desolate.

"The banks rise nearly 300 feet above the level of the stream, and are more than a mile apart. They are almost bare of vegetation, and marked by bands of different colored clays and sandstones in a nearly horizontal position, as far as the eye can reach. The descent into the valley cannot be made on horseback but by taking advantage of the well-worn buffalo tracks, which are found leading down almost every coulée and ravine. The river itself is comparatively insignificant, and winds in broad curves from side to side of the valley, and is fringed by a grove of large poplar trees, and by willows. The bottom of the valley is marked out into three distinct levels, differing much in appearance, though only by a few feet in height. Over the first of these the river must constantly pass in flood. It shows in many places a luxuriant growth of grass, and supports most of the timber. The second level, which the river can seldom if ever touch, is characterized by the abundant growth of *Artemisia* of several different species. The third level, which forms a kind of low terrace at the foot of the cliffs, and must be twenty to thirty feet above the stream, consists of hard, parched clay, the washings of the banks, and nourishes only the grease-wood, and a few other thick-leaved drought-loving plants.

"The sections on the banks are undisturbed and regular. The beds ^{sections,} are divided into an upper and lower series, by a zone of sandstones, which is about two-thirds up the bank near the Line, but about eight miles north-westward up the valley, is found forming the very summit of the cliff; which here, from the better support afforded by such hard rocks as compared with the clays and arenaceous clays of the rest of the formation, assumes a bolder and more rugged aspect, and a greater height than elsewhere. Fourteen miles south-eastward of the crossing of the Line, the same sandstone zone is again seen, but now only about one-third up the bank, indicating a general inclination of the beds in a south-easterly direction—which may not be exactly that of the full dip—of about ten feet to a mile.

"The sandstones, though often well and evenly bedded, are not regularly hardened, but have a nodular character; and though in some localities indurated throughout their entire thickness, in other places not far removed, they may show only certain hard layers of comparatively small thickness, separated by beds of unconsolidated sand. They appear, however, to be very constant in extent, and do not differ materially in thickness at the several localities where they were examined. They are slightly ferruginous, with prevailing light yellow tints, and are often more or less affected by false bedding.

Sandstones.

*Rocks below
sandstones.*

*Origin of
lignite.*

Fossils.

*Vertebrate
remains.*

"Below the sandstones occur clays, sands, and arenaceous clays generally well stratified, and individual beds of which may often be traced a long way up or down the valley. The colors are usually light, but there are some zones of darker carbonaceous clays, and in a few places impure lignites of no great thickness were observed. These appeared to be less persistent than most of the other beds, and generally to thicken and disappear when followed far in either direction. From their appearance, and mode of occurrence, these lignites may well have originated from the drifting together of wood or peaty matter, and differ considerably from the pure and definite beds which characterize the Lignite Tertiary further east, and which appear to be formed of trees which have grown on the spot.

"Above the sandstone zone is a great thickness of sands and arenaceous clays, forming more massive beds, in which the stratification is less perfectly marked. The general tints are pale greenish-grey, greyish, and light buff.

"No fossils were found in this upper series or in the sandstones. In the beds below the sandstones, organic remains are also singularly rare, but are not altogether absent. In a part of the section not far below the base of the sandstone zone, is a layer with great arenaceous concretions, which contain in some places abundance of fossils."

Amongst these are *Campeloma productum*, one or more species of *Vivipara*, two species of *Corbula*, a *Helix*, and *Sphaerium formosum*, var.

"A few rolled fragments of bones are also included in the bed, and some traces of fossil plants. Lower down in the section valves of *Ostrea* are found, sparingly scattered through the deposit, and not very far from the base, a layer containing shells of *Unio* in a poor state of preservation was observed. Near the latter were found fragments of the bones of a large vertebrate. They were scattered, and not in a very good state of preservation, and had evidently been strewn about after the death of the animal, and before their envelopment by the sediment. These, with the other vertebrate remains, were submitted to Prof. Cope, who pronounced them to be portions of the sacrum and long-bones of a Dinosaurian.

"A section of the upper beds and sandstones, observed in a ravine on the east side of the Great Dry Coulée, near the Line, showed the following succession of beds:—

* The names of fossil molluscs here given have been revised by Mr. Whittleaves in conformity with his later researches.

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FEET. INCHES.

1. Light yellowish arenaceous clays and sands, indicated in slopes and higher grounds, but of which a few feet at the base only are well exposed	6	8
2. Grey sand	4	5
3. Grey-green arenaceous clay.....	9	0
4. Arenaceous clay (rusty, irregular layer).....	2	3
5. Highly ferruginous layer. A few inches.		
6. Grey arenaceous clay, rather conspicuously banded....	17	10
7. Grey soft sand-stone	14	5
8. Sandstones, hard and soft, brownish, yellowish and grey; often concretionary, generally well stratified, but sometimes false-bedded, forming cliffs in the gorge, and weathering out into overhanging ledges, and horizontally fluted walls.....	35	6
About.....	90	0

"The most complete section of the beds below the sandstone zone ^{Most complete}_{section.} was obtained about eight miles north-westward from the intersection of the valley with the Line, and on the north-east side of the valley. It may overlap the last by a few feet, or a few feet may be omitted; but, allowing for this slight uncertainty, it forms a continuation downward of the base of the former section.

FEET. INCHES.

1. Soft grey sandstone, forming the top of the bank (about).....	4	6
2. Red-brown concretionary sandstone, with large flat- tened nodules.....	4	6
3. Hard grey sand	4	5
4. Reddish nodular sandstone.....	2	0
5. Whitish arenaceous clays, with some selenite in the lower layers.....	22	6
6. Greyish and yellowish arenaceous clays (banded) ..	13	4
7. Yellow-grey arenaceous clay.....	11	0
8. Greyish arenaceous clay in which stratification is scarcely apparent	71	4
9. Yellowish sandstone, thin bedded.....	2	0
10. Grey arenaceous clay.....	4	5
11. Purplish shale	1	6
12. Grey arenaceous clay.....	5	6
13. Brown shale, with imperfectly preserved plant re- mains.....	0	6
14. Grey arenaceous clay	14	8
15. Purplish shale, with some thin layers of impure lignite.....	8	10
16. Purplish-brown shale	1	0
17. Greyish arenaceous clay.....	7	7
18. Grey arenaceous clay, upper part shaly	11	1

	FEET. INCHES.
19. Yellowish arenaceous clay	4 5
20. Purplish shale.....	1 0
21. Yellowish arenaceous clay.....	8 11
22. Purplish shale	2 2
23. Greyish arenaceous clay	6 9
24. Sandstone, a few inches,	
25. Greyish arenaceous clay	4 6
26. Yellowish arenaceous clay (lowest bed in which remains of molluscs were found at this place. <i>Ostrea</i>)	4 5
27. Nodularly hardened sandstone	1 0
28. Yellowish arenaceous clay	31 0
Concealed in slope to river, about	30 0
About.....	284 10

Thickness.

"The thickness of beds displayed in the above sections, when combined, is about 375 feet, and the bottom of the river-valley is, probably not very far above the base of the Lignite Tertiary formation. It will be observed that the genus *Ostrea*, is here for the first time mentioned as occurring in these beds; further west it becomes one of the most usual forms. The conditions of deposit implied by the beds on the Milk River, are those of an estuary, or shallow sea margin, where, while oysters and corbulas were living, the remains of fresh-water shells and land vegetation, were being carried and mingled with them."

Conditions of deposit.

"The superposition of these beds on the Cretaceous clays of group 4, is not clear in this locality, as no junction of the two formations was observed. Their lithological character, might almost seem to render it probable, that they represent the same series as that supposed to come up from below the Cretaceous clays between the East and West Forks of Milk River."

Correlation of beds.

This latter supposition has been confirmed by the work done since the above description was written, as the rocks shown in the valley of Milk River have been traced northward to Many Berries Creek, and from thence on to the head waters of Sage Creek, at which point they are plainly seen to be overlaid by the Fort Pierre shales.

Supposition confirmed.

The plains between Milk River and Many Berries Creek, near the international boundary, have a height of about 2,900 feet, but going north towards the south-west corner of the Cypress Hills, the elevation rapidly increases, and near the base of the hills it exceeds 4,000 feet. A few miles north of Many Berries Creek, proceeding in a northerly direction, the edge of a low plateau running north-west and south-east is reached. This plateau had been deeply gashed in many places along its south-western slope by coulées running back from Many Berries Creek and cutting deeply into the soft argillaceous and arenaceous

Elevation of Plains.

Low plateau.

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ocks of the Belly River series, which constitute its principal mass. Near the summit of the plateau, at an elevation of about 3,000 feet the Belly River series is overlaid by the Pierre shales. The superposition of the Pierre on the Belly River series is clearly seen in many of the sections along the edge of the plateau, especially on those occurring on the branches of Sage Creek. This stream heads in the Sage Creek,

plateau, in which its numerous branches have carved out a deep bay, and flows south-eastward, crossing the forty-ninth parallel a few miles east of Wild Horse Lake. Near the Line, the banks are low and enclose a wide, desolate clay flat, on which nothing grows except sage-bush and cactus. Farther up, the banks of the valley become higher and sections of rock begin to appear. At one point, this stream has

change in
course of
stream.

been diverted from its old valley, probably by some obstruction during the glacial age, which has turned it to the east, and it runs for several miles through a narrow valley, with steep-cut banks, before it regains its former channel. The newer valley was probably partly formed by meandering coulées before it became the bed of the main stream. In its upper part Sage Creek divides up into a number of branches, all of which possess deep valleys and exhibit very fine sections of the rocks belonging to the upper part of the Belly River series and the basal portion of the Pierre shales. North of Sage Creek, the junction of the

Junction
marked by low
plateaus.

Pierre and Belly River series is marked by a series of low plateaus, trending westward, and extending in a somewhat uneven line in a direction a little west of north to Bull's Head plateau, beyond which point they turn to the east.

The superposition of the Pierre shales, on the more arenaceous and lighter colored beds of the Belly River series, is unmistakably shown in a great number of places along the western slopes of this range of plateaus, and puts the question of the relative position of the two formations beyond doubt.

East of these plateaus, the Pierre shales become the surface formation, except where overlaid by the elevated Laramie plateaus, and continue so for a great distance; their easterly dip of about 10° to the mile, agreeing very closely with the decline of the whole country in the same direction. Their presence is indicated by numerous exposures in the banks of all the principal valleys and also by the hard clayey and sterile nature of the soil, a feature which nearly always characterizes soils owing their origin to this formation.

The East and West Forks of Milk River afford good exposures of the shales in the upper parts of their courses, but near the boundary they become concealed by the heavy drift deposits. The drift is, however, almost entirely derived from the underlying shales, and it frequently contains clay-ironstone nodules, and also fragments of the more common fossils of the formation.

Belly River
series.

Heavy dip.

Interesting
section.

Section.

The rocks of the Belly River series are brought to the surface, and spread over a limited area, a few miles east of the West Fork in Township 1, Range xxvii, W. 3rd Principal Meridian. They are brought up quite suddenly by a heavy southerly dip from beneath the shales which they underlie conformably. This area was examined by Dr. G. M. Dawson, in 1874, and the following description is quoted from him.*

"A most interesting section occurs in a deep valley about six miles west of East Fork. Exactly on the Boundary-line, the banks show good exposures of the Cretaceous shales, more closely resembling in their lithological character those seen in the upper part of the Pembina Mountain sections, than those of the same beds as occurring in the vicinity of Wood Mountain. The rock is almost, or quite horizontal, is pretty hard, and well stratified, and includes white bands like those already referred to. On following the valley about a mile northward, these clay shales seem to bend suddenly upward and give place to a series of rocks, which appear to underlie them, and which differ from them altogether in character, and include massive layers of sandstone and thick arenaceous clays.

"A section was measured across the upturned edges of these beds, which is given below, the measurements being reduced, so as to represent the actual thickness of the strata. The section—supposing no reversal to have taken place—is in descending order:—

	FEET. INCHES.
1. Sombre Cretaceous clay-shales, Division 4, M. and H.	
2. Gray and yellow arenaceous clays, with some remains of <i>Ostrea</i> in the lower layers (about).....	20 0
3. Greyish-white arenaceous clay, with irregular sheets of ironstone	8 6
4. Carbonaceous shale.....	1 0
5. Grey arenaceous clay.....	2 6
6. Black carbonaceous shale	2 0
7. Dark shales, with carbonaceous bands.....	12 6
8. Carbonaceous shale, with poorly preserved plant remains.....	1 6
9. Grey arenaceous clay.....	30 0
10. Brown shale, with indistinct impressions of plants, a few inches.	
11. Grey arenaceous clay.....	3 6
12. Laminated carbonaceous shale, with spots of amber, and impressions of plants.....	2 0
13. Grey and yellow arenaceous clay.....	20 0
14. Yellowish arenaceous clay.....	11 0
15. Grey arenaceous clay.....	9 0

* Geology and Resources of the 49th Parallel, p. 114.

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	FEET. INCHES.
16. Soft beds — probably yellowish arenaceous clays, but not well exposed.....	35 9
17. Grey sandstone, weathering yellow, and with many jointage-cracks.....	12 10
18. Greyish arenaceous clay	45 11
19. Hard sandstone, breaking into large rectangular fragments, and weathering into pot-holes.....	4 0
20. Soft arenaceous clays.....	12 10
21. Fine-grained grey-yellow sandstone, with dendritic markings.....	2 0
22. Grey and yellowish arenaceous clay, with some thin sheets of ironstone.....	34 5
23. Red-brown sandstone.....	2 0
24. Soft grey sandstone	6 5
25. Nodular brown sandstone	0 6
26. Soft beds, with some thin sandstone layers.....	24 0
27. Nodular red-brown sandstone, (about)	3 0
28. Greyish and yellowish arenaceous clays, well strati- fied, and with small fragments of some Lamel- branchiate shell at the base.....	88 5
29. Greyish and yellowish arenaceous clays, well strati- fied	121 10
30. Sandstone.....	3 0
31. Brownish arenaceous clays, crumbling and rotten where exposed.....	134 4
32. Grey sandstone (Dip 45°).....	1 6
33. Yellowish sandstone, thin bedded and flaggy.....	34 0
34. Purplish and brownish clays, with evident strati- fication lines.....	47 7
35. Impure ironstone.....	1 0
36. Purplish shaly clays	127 3
37. Impure ironstone.....	1 0
38. Crumbling earthy clays.....	26 6
	893 7

"The beds below these are not exposed sufficiently well to enable the section to be measured. From blocks of sandstone strewing the banks, however, it is probable that one or more layers of this rock occur not far below the base, as here given.

The strike of these beds is N. 27° E. (mag.) and their dip, south-east- Tilting of
ward, at angles varying from 45° to about 30°. The tilting of strata remarkable.
to such angles as these—even if the existence of no more violent
flexure be suspected—is in itself a circumstance sufficiently remarkable,
in a country where, for hundreds of miles, the rocks are found with Rocks seldom
inclinations no greater than can be accounted for by original irregu- much inclined.
larities of deposit. The nearest disturbed region is that in the neighbourhood of the Buttes, and the upturning is there in immediate connection with the extrusion of igneous matter."

Age of disturbed beds.

East Fork of Milk River.

Range of plateaus.

Old-man-on-his-back plateau.

Composition.

Rounded ridge.

Boundary plateau.

There is little doubt that the upper part, if not all of the beds brought up so unexpectedly in this place belong to the Belly River series. This is shown by their stratigraphical position, and also by their holding at one point numerous specimens of *Corbula perundata*, one of the most characteristic fossils of that formation. Some of the lower beds may belong to the same series as the lower dark shales found north of the Buttes on Milk River. The junction of the Belly River series and the Pierre shales along the southern edge of this disturbed area is clearly shown, but as the northern contact is concealed, it is impossible to say whether the presence of the underlying beds is due to a simple anticlinal swell, or if they are faulted along their northern border, though the latter hypothesis seems the more probable one. In either case, the high angle at which these beds lie is a quite anomalous occurrence in this district.

The East Fork of Milk River after leaving the neighbourhood of the Cypress Hills, possesses little geological interest, as the insignificant sections seen along its valley show scarcely anything but drift. An exposure of Fox Hill sands was found at one point, near the extremity of a sharp bend which it makes to the east, about twenty miles north of the boundary.

Proceeding in an easterly direction from this stream along a plain with an elevation of about 3,000 feet, the next point of interest which is reached is the range of low westward-facing plateaus, which extends from the boundary near Range xxiii., W. 3rd Principal Meridian in a north-westerly direction. Old-man-on-his-back plateau, the most northerly member of this range, is about four miles long and about 450 feet high. To the west it presents a steep scarped face, but in all other directions slopes gradually away. Its surface is undulating, and in its highest part very sparingly covered with drift. The beds which enter into the composition of this plateau, are well exposed on its western slope, and are there seen to consist of about 300 feet of Pierre shales, capped by about 150 feet of yellowish Fox Hill sands and sandstone. A few thin beds of nodular sandstone near the top of the Fox Hill have served to arrest the work of denudation, and to preserve the plateau. A range of high rolling hills continues on from the plateau in a north-easterly direction for several miles. South-east of Old-man-on-his-back plateau, and separated from it by a wide valley, is a long rounded ridge much lower than the plateaus either north or south of it, and composed entirely of Pierre. The third plateau, which extends to the boundary, is of more importance than the other two, as it re-introduces the Laramie with its accompanying carbonaceous zone. Good exposures occur along the western face of this plateau. The lowest beds seen consist of Pierre shales of the usual kind. Above these comes the Fox Hill,

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here about fifty feet thick. This formation looks a good deal greyer than is usually the case, and contains a considerable quantity of hard sandstone in places. The Fox Hill is succeeded conformably by the Laramie, the lower part of which consists of a conspicuous band of white and grey clays and sands, fifty-five feet thick, holding a seam of lignite from two to three feet in thickness. The lignite in this seam is of fairly good quality, and will become valuable for local purposes so soon as the country in its vicinity becomes settled. It has been burnt *in situ* in a number of places along the escarpment. It is overlaid by a bed of dark clay, twenty feet thick, which looks exactly the same as a bed occupying a similar position in the Cypress Hills. The upper part of the Laramie consists of about fifty feet of yellowish and greyish silts interstratified with some thin beds of clay and sand. The Laramie deposits at this point bear a strong general resemblance to the beds occupying the same relative position in the east end of the Cypress Hills and north of Wood Mountain. The surface of this plateau is undulating and near the summit becomes very rough. Towards the east and north it slopes gradually down to the prairie level and no exposures occur. A thick bed of pebble conglomerate was found in a depression a couple of miles east of the west end of this plateau. This bed resembles exactly the Miocene conglomerate of the Cypress Hills, but it probably agrees more closely in age with the more recent deposits of a similar character found south of the "Gap" of the Cypress Hills, and in the valley of the Saskatchewan, which have been referred to the Pliocene. The beds underlying the conglomerate are not exposed but are probably Pierre.

East of this plateau an undulating plain, based on the Pierre shales, but affording no exposures, extends all the way to the White Mud River.

GEOLOGY OF WOOD MOUNTAIN.

Wood Mountain is simply a westward projecting spur of the Côteau Laramie area. Its geology is very simple, as the plateau is composed of an undisturbed and conformable series of strata, referable in descending order to the Laramie, the Fox Hill and the Pierre shales. The whole system has a dip in an easterly direction, of about ten feet to the mile. Dip of system.

On approaching Wood Mountain from the north, along the Moosejaw and Wood Mountain trail, exposures of rock are first met with in the vicinity of Twelve-mile Lake. This lake, which occupies the abandoned channel of some ancient stream, is hemmed in by high banks, which afford excellent sections of all the formations found in the district. Near its western end, the exposures consist of Pierre shales only, but

going east along the lake, the Fox Hill and Laramie descend successively to its level.

Pierre
unfamiliar in
appearance.

Fossils scarce.

Boundary of
Laramie.

Divisions of
Laramie.

Plateau
irregular.

Exposures
small.

The upper portion of the Pierre shales, north of Wood Mountain presents a somewhat unfamiliar appearance, where seen in the sections around the lake and in the numerous coulées leading from the hills, as it has become greyer in colour and more arenaceous than the typical variety, and its foliation is also much coarser. These grey arenaceous shales are occasionally directly overlaid by the Laramie, but more frequently a varying thickness of coarse-grained, yellowish sandstone, representing the Fox Hill, intervenes between the two. Very few fossils were found in those sandy shales, but one section, after careful examination, in addition to some of the more common fossils of the formation, yielded specimens of *Scaphites subglobosus* and *Anchura Americana*.

In the western part of Wood Mountain, the boundary of the Laramie is coincident with the edge of the plateau, but farther east, owing to the easterly dip of the formation, it leaves the hills and turns away to the north, and at Twelve-mile Lake, the plain between it and the foot of the plateau is based entirely on the Laramie. This plain, which has a northerly slope of about fifty feet to the mile, is seamed in all directions by coulées issuing from the hills.

The Laramie strata north of Wood Mountain include three somewhat dissimilar groups. At the base there is a series of yellowish sands, silts and clays, holding small interstratified beds of ironstone, part of which may be referable to the Fox Hill. This is overlaid by a very conspicuous band of whitish and greyish argillaceous sands, silts and clays, interstratified with a thick band of carbonaceous shales, which often includes a small lignite seam of inferior quality. This seam has been burnt in a number of places. The third group consists of yellowish silts, sands and sandstones, with an occasional bed of hard nodular sandstone. Although none of the beds in this section maintain the same composition for any distance, and false bedding and other irregularities implying deposition in shallow water, are of frequent occurrence, yet the distinction between the different zones is remarkably persistent, and holds good as far west as Cypress Lake in the Cypress Hills.

East of Wood Mountain Post, the plateau is extremely irregular and broken, a fact due to the multitude of streams and coulées which intersect it in all directions. The banks of most of these valleys are unfortunately, usually grass covered and the geological information they afford is very meagre and unsatisfactory. The few exposures which do occur are very fragmentary and show yellowish and greyish silts, sands and sandstones, belonging to the upper portion of the Laramie. A thick bed of hard sandstone was found near the surface in a number of places and small beds of lignite are of not infrequent occurrence. The

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most valuable seam that was examined is situated about eleven miles east of Wood Mountain Post, in Township 4, Range i., West of the 3rd Principal Meridian. This seam, which has been worked to some extent, is about six feet thick and is of very fair quality. It is associated both above and below with sandy clays. The lignite from this seam was used with satisfactory results by the North-west Mounted Police for blacksmithing purposes, when they were stationed at Wood Mountain. A large stream of cold water collecting on the impervious surface of this bed issues from the bank and pours over its face near the place where it has been worked.

Another seam of a workable character was observed a few miles further west in Township 4, Range ii., West of the 3rd Principal Meridian. This seam is well exposed in the side of a hill south of the trail. The following section was measured here:—

	FEET. INCHES.
1. Yellowish sandy clay.....
2. Carbonaceous shale.....	2
3. <i>Lignite</i>	8
4. Carbonaceous shales.....	1 1
5. <i>Lignite</i>	4 6
6. Carbonaceous shales.....	1 0
7. Sandy clays.....

Going south from Wood Mountain Post, no exposures of any kind were met with until the southern escarpment of the plateau was reached. At this point, a thick bed of nodular sandstone projects from the slope near its bank, and above it small sections of yellowish silts and sands appear in the bank.

The southern edge of Wood Mountain plateau is low, is usually well grassed, and is consequently suffering little from denudation at present. It has been forced back to its present position by the united erosive energies of Poplar River and Rocky Creek. These two streams are still separated by a low diffuse ridge, which is, however, rapidly undergoing degradation. The western slope of this ridge has been worn into bad lands by branches of Rocky Creek which penetrate it in all directions. The sections exhibited in these Bad Lands were examined by Dr. G. M. Dawson in 1874, and the following detailed description is quoted from his report*:—

"The most instructive section, however, in the Wood Mountain region, lies twenty miles south of the settlement of that name, on the forty-ninth parallel near the 425 mile point from Red River. Here beds undoubtedly belonging to the Lignite Tertiary formation—which, east

Section south
of Wood
Mountain.

* Geology and Resources of the 49th Parallel, pp. 92-103.

of this locality has covered so great an area of country—are found clearly superposed on indubitable Cretaceous rocks. The exposures are numerous, and are produced by the streams flowing from the southern escarpment of the water-shed plateau, above referred to, which has here been gashed by their action into most rugged *Bad Lands*.

Description of
bad lands.

" This term has attached to it in the west regions of Amerien a peculiar significance, and is applied to the ruined and desolate country formed where the soft, clayey Tertiary formations are undergoing rapid waste. Steep irregular hills of clay, on which scarcely a trace of vegetation exists, are found, separated by deep, nearly perpendicular-sided and often well nigh impossible valleys, or, when denudation has advanced to a further stage—and especially when some more resisting stratum forms a natural base to the clayey beds—an arid flat, paved with the washed down clays, almost as hard as stone when dry, is produced, and supports irregular cones and buttes of clay, the remnants of a former high level plateau. Denudation in these regions, proceeds with extreme rapidity during the short period of each year, in which the soil is saturated with water. The term first and typically applied to the newer White River Tertiaries of Nebraska, has been extended to cover country of similar nature in the Lignite Tertiaries of the Upper Missouri, and other Tertiary areas of the west. In the bad-lands, south of Wood Mountain, the hills assume the form of broken plateaus degenerating gradually into conical peaks, when a harder layer of sandstone, or material indurated by the combustion of lignite beds, forms a resistant capping. Where no such protection is afforded, rounded *knobs* are produced from the homogeneous arenaceous clays. Waste proceeds entirely by the power of falling rain, and the sliding down of the half liquid clays in the period of the melting snow in spring. The clay hills are consequently furrowed from top to base, by innumerable runnels converging into larger furrows below. The small streams rapidly cutting back among these hills, have formed many narrow steep-walled gullies, while the larger brooks have produced wide flat bottomed valleys at a lower level, in which the streams pursue a very serpentine course. Denudation is even here, however, going on, as from the frequent change in the channel of the stream, it is constantly encroaching on the banks of the main valley, under-cutting them and causing land slips. The method of the immense denudation of Tertiary beds, which is proved to have taken place over the area of the western plains, is explained by the degradation still going on in this way along their present borders.

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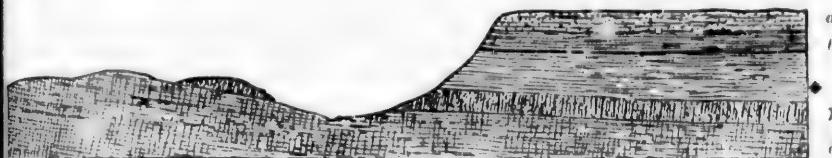
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SECTION IN BAD LANDS SOUTH OF WOOD MOUNTAIN.

The asterisk indicates the horizon at which vertebrate remains were found.)

"Taking first the highest bed seen, the order is as follows:—

"(α) Yellowish sand and arenaceous clay, sometimes indurated in certain layers and forming a soft sandstone. It forms the flat plateau-like tops of the highest hills seen. *About 50 feet.*

"(β) Clays and arenaceous clays, with a general purplish-grey color when viewed from a distance. *About 150 feet.*

"(γ) Yellowish and rusty sands, in some places approaching arenaceous clays, often nodular. *About 80 feet.*

"(δ) Greyish-black clays, rather hard and very homogeneous, breaking into small angular fragments on weathering, and forming earthy banks. *About 40 feet seen.*

"The whole of the beds appear to be conformable, and disregarding minor irregularities, are quite horizontal to the eye.

"The clays and arenaceous clays of the upper part of Division β are very regularly bedded, and include a lignite-bearing zone. Three lignite beds, of from one to two feet each in thickness, were observed, but they are separated from each other by rather wide clay partings, and are not pure or of good quality. A bed rich in the remains of plants immediately overlies the upper lignite. It is composed of a very fine, and nearly white indurated clay, in which the most delicate structures are perfectly preserved. From its soft and crumbling character, it is almost impossible to obtain or keep good specimens; but, in the fragments which were preserved, a few very interesting plants appear. Of these, some are characteristic of the Fort Union group, and identical with those of Porcupine Creek. The association of remains is that of a fresh water pond or lake, and a fine new species of *Lemna* occurs abundantly.

"In the lower portion of this division, the beds are more sombre in tint, and little differentiated by colour, which elsewhere often renders the stratification apparent. They contain some layers of sand and

sandstone, which show much false bedding and current structure, and sometimes terminate suddenly with abrupt undulations. In some places, sufficient calcareous cement has been introduced among the grains to form hard sandstones, but their thickness is never great, nor do they extend far. Much ironstone occurs in thin nodular layers, and some selenite. About one third from the base of this division a bed was found, in which curious fruits have been preserved, referable to a new species of *Aesculus*.*

Fossil fruits.
Vertebrate remains.

"The most interesting feature of this part of the section, however, is the occurrence of the remains of vertebrate animals. They are found exclusively in the lower portion of this division, and most of them below the fruit-bed just mentioned. They are generally closely connected with the ironstone layers, and are often themselves impregnated with that substance. They are also, unfortunately, apt to be attached to the ironstone nodules, or incorporated with them, and traversed by crack-lines, in such a way as to render it difficult to obtain good specimens. A more prolonged search among these hills, than I was able to make would, however, no doubt result in the discovery of localities where the remains are more abundant and in better preservation.

"Professor Cope has kindly examined the vertebrate fossils obtained in connection with the expedition. Those from this place include fragments of several species of turtles, scales of a gar-pike, and broken bones of dinosaurian reptiles. Of the turtles, two are new species, to which Professor Cope has given the names—*Plastomenus costatus*, and *P. Coalescens*—and there are portions of species of *Trionyx* and *C. pseomys*. The gar-pike belongs to the genus *Claes*, and of the dinosaurian remains, though mostly too fragmentary for determination, a caudal vertebra resembles that of *Hadrosaurus*.

Fox Hill series.
Division (γ), the lower series of yellow sands and arenaceous clays, is a much better defined member of the section than Division (α). It is exposed chiefly in the banks of the smaller ravines, but also in the upper parts of those of the main brooks. The nodules which it contains are large and irregular, but often approach more or less closely to a spherical form. They are arranged in horizontal lines in the exposures. No fossils were found in this part of the section.

Marine fossils.
"The line of separation between divisions (γ) and (δ), is quite well marked by the change in color. The latter shows scarcely a trace of stratification lines. I was very anxious to obtain fossils from it, but succeeded only in collecting a few small fragments. They, however, indicate purely marine conditions; and one of them is referable to the genus *Leda* or *Yoldia*. The identification of the horizon of this bed

* *Aesculus antiquus*. The following plants were also found here—*Lemna* (*Spirodela*), *Scirpus*, *Sapindus aefinis*, *Trapa borealis*, *Carpobrotus*.

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does not, however, depend on such slight grounds as these, as it was afterwards traced westward, and found to be continuous with well-marked fossiliferous Cretaceous rocks.

"Divisions (α) and (β) of this section, clearly belong to the Lignite Correlation of beds. Tertiary. They probably represent, however, merely the lower layers, and differ somewhat in lithological character and arrangement, from those seen at Porcupine Creek, thirty miles east of this place, and at other localities still further eastward. These beds, no doubt, belong to a lower part of the series than is exposed in any of the sections examined between this locality and the Missouri Côteau, and are probably also older than any of those found in the Souris valley. The beds described as occurring on the trail, south of Wood Mountain, belong to about the same horizon, and it is probable that those seen in some places on the Traders' Road, may not be much higher up in the series. It would appear that the conditions most favorable to the formation of deposits of lignite, did not occur frequently or continue long in the earlier stages of the formation in this locality.

"Division (δ) being certainly Cretaceous, it only remains to classify division (γ), which is so markedly different in character from the beds above and below it. This bed, I believe, represents group No. 5 of the Cretaceous, or the Fox Hill group of Meek and Hayden. It was frequently observed at other places further west, and its relations will be more fully discussed in the sequel.

"The lignite beds occurring in division (β), have been burned away Burnt lignite beds. over great areas in this region. Numerous red-topped hills are seen, the capping being composed of indurated clays and sandstones, often with much the colour and appearance of red brick. The tops of these hills are all nearly on the same plane, and this, if traced back into some of the larger hills and edges of the plateau, exactly coincides with the zone there still containing the lignite. The beds, as there exposed, however, seem hardly of sufficient thickness or importance to cause an alteration of the strata so extensive as has taken place. It is possible from the irregular nature of these deposits, that over the areas destroyed by combustion, the lignite has been thicker and of better quality, and that the fire may have been unable to extend itself into the thinner portions of the bed, where it is separated by clay partings and covered by such a great thickness of other deposits. The combustion must have taken place ages ago, as isolated red-topped buttes now only remain to mark what must have been the level of the plain at that time."

West of the bad-lands, the Cretaceous rocks are soon brought to the surface by the general easterly dip, and rise rapidly in the plateau. A few sections occur at intervals along both northern and southern slopes, but as they differ in no material respect from those found further east, a Sections west of bad lands.

description of them would only be a repetition of what has already been written.

A ridge of high land connects Wood Mountain with the White Mud River plateau, the summit of which may still be crowned with some lingering remnants of its former Laramie covering, but I was unable to find any sections in which they were exposed.

WHITE MUD RIVER SECTION.

The rocks shown in the valley of the upper part of the stream, west of East End Coulée, have been described in that part of the report which treats of the Cypress Hills. East End Coulée is a deep wide valley, which runs along the eastern escarpment of the Cypress Hills, and connects a branch of Swift Current Creek with the White Mud River. West of it the river section is upwards of 500 feet deep, while on the eastern side it sinks to about 250 feet, and is composed principally of Pierre shales, with, in some places, a thin capping of Fox Hill sandstones. Further down the Fox Hill sandstones disappear and the banks are composed entirely of Pierre. The valley at this point is about 200 feet deep, and about a mile wide. The Fox Hill sandstones are not long absent, but re-appear in the course of a couple of miles, and are soon followed by the Laramie, the river having entered the White Mud River plateau.

East End Coulée.

White Mud River plateau.

Composition of plateau.

The White Mud River plateau is a low diffuse irregular elevation, situated mid-way between the Cypress Hills and Wood Mountain. It is separated from the former by a depression about eight miles wide, but is connected with the latter, by a ridge which flanks the White Mud River on the north for some distance. This plateau has an average width of about twenty-five miles from north to south, and is about forty miles long, but is quite narrow for half the distance. It has a height of about 300 feet above the plains around it, and of 3,375 feet above the sea. Its surface is very rolling, and is broken up by a large number of coulées, most of which are tributary to the White Mud. The edges of the plateau, though sometimes abrupt, are usually very gradual, and are nearly always grass-covered, and as they afforded exposures at only one or two points, the boundaries of the Laramie, as laid down on the map, are based mainly on differences in elevation, and can only claim to be an approximation.

White Mud River plateau, like most of the plateaus in the district, is composed of Laramie overlying Fox Hill and Pierre. Exposures of these formations are almost entirely confined to the valley of the White Mud River, which cuts across the southern part of the plateau, but the Laramie is also seen at one point in the northern face, where a small

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branch of Swift Current Creek has cut back into it. The section in this coulée contains a band of coarse yellowish sandstone, about twenty feet thick, above which comes seventy-five feet of alternating sands and clays, and following this a carbonaceous zone, containing a couple of lignite seams around which the following section was measured:—

	FEET. INCHES.
1. Greyish, shaly clays.....	1 0
2. Carbonaceous shale.....	0 9
3. <i>Lignite</i>	1 6
4. Carbonaceous shale.....	0 0
5. <i>Lignite</i>	1 1
6. Yellowish, sandy clays.....	1 0
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The thick bed of sandstone in the bottom of the section is probably Fox Hill sandstone, on which the plains north of the plateau seem to be based, as exposures of it were found in a couple of places further down on the same valley.

The Laramie re-appears in the upper part of the banks of the valley of the White Mud, about ten miles east of East End Coulée. A grey band, composed of light colored sands and clays, appears first near the surface and bears a very close resemblance to the rocks occupying the same horizon in the Cypress Hills and like them is overlaid by some carbonaceous beds. Further down, these beds become much darker in color, and contain a larger proportion of clay and also assume a somewhat banded appearance. At this point, the small alternating beds of greyish, yellowish, greenish, and dark colours, give the section a look somewhat similar to the rocks near the base of the Laramie on Little Bow River. This striped band is overlaid by fine-grained yellowish argillaceous sands and sandstones, and rests on the Fox Hill. The sections along this part of the river are very good and show about 250 feet of Laramie beds. The Laramie gradually descends in the banks and reaches the bottom of the valley about twenty miles east of East End Coulée. At this point, the bottom of the section is nearly always concealed by the talus, but the few exposures visible seem to show that the beds are horizontal for a short distance, and then dip westward at Dip. an angle sufficient to bring them to the surface about eight miles further down; near the angle of a sharp bend which the river makes to the north. Beyond this point, the river runs in a northerly direction for several miles, and follows very closely the edge of the Laramie, exposures of which occur in the western bank of the valley. The eastern bank is lower and shows Pierre and Fox Hill only. The northerly reach of the river is about eight miles long, after which it again turns to the east. Near the bend it is joined by a large coulée which

Coal seams.

Sections in valley.

Fossils.

Fox Hill plateau.

Deep valley.

Land-slips.

Thickness of clays.

rises far back in the plateau and shows some very fine sections of the formations composing it. In the banks of this coulée, a couple of miles from its mouth, the Laramie was observed to contain two coal seams each about two feet thick.

The Laramie is seen in the northern bank of the valley for a short distance below the bend, but soon disappears and is replaced by Pierre and Fox Hill. The valley below this point enlarges considerably, and becomes exceedingly rough, and its scarped banks, in many places, afford sections of Cretaceous strata upwards of 300 feet thick. These sections show a tendency in the Pierre to become lighter coloured and more arenaceous above, a feature which becomes much more pronounced further north. Fossils imbedded in ironstone and calcareous nodules occur in many places, and are usually more abundant some distance down in the formation; the upper part being apparently rather barren.

Near the crossing of the trail between Wood Mountain and the Cypress Hills, the banks become somewhat lower and are less frequently scarped, and they often enclose wide clay flats, covered with a heavy growth of *Artemisia*. Below the crossing, the valley continues to bear a somewhat similar character until within a few miles of the boundary, where it encounters a small Fox Hill plateau, and its banks at once become much higher. The following detailed description of the rocks exposed in the valley near the boundary line is quoted from Dr. Dawson* :—

"Where the line crosses White Mud River; or, Frenchman's Creek, numerous and very fine exposures of the Cretaceous rocks occur. The stream flows in the bottom of a great trough, cut out of the soft Cretaceous strata, over five hundred feet deep, and in some places fully three miles wide. Many ravines enter this valley from the sides, and numerous land-slips have brought down the upper beds to various levels in its banks, and have produced a rugged mass of conical hills and ridges. The tops of the banks on both sides of the valley are formed of yellowish ferruginous sands, referable to division (γ), of the Bad Land section. They are in many places, hardened into layers of sandstone, and are nowhere very soft. Land-slips have confused the section, but they can be traced in their original position as far up and down the valley as can be seen. I could find no fossils in these beds, though sixty to seventy feet of them must be visible in some places.

"Below these are sombre Cretaceous clays of division δ , and they extend downward to the water level of the river; showing a thickness of 273 feet, the base not being seen. The portion of these clay shales most

* Geology and Resources of the 49th Parallel, p. 109.

nearly resembling those last described, and those of the Pembina Mountain series, lies immediately below the yellow sands; below this, to the bottom of valley, they show rather the crumbling earthy character and more sombre-colour of the Bad Lands and Wood Mountain astronomical station exposures. This would tend to prove that rocks like those of the upper part of the typical Pembina Mountain series, are not confined to any particular horizon in the western representatives of that group. About one hundred feet below the base of the yellow sands, a bed characterized by the great abundance of the remains of a fine species of *Ostrea*, occurs. It is referable to *Ostrea patina* of Meek and Hayden; and fragments of a thick *Inoceramus* occur in the same stratum. The Ostreas, for the most part, are quite perfect, and have been entombed where they grew, the valves being still attached. They are frequently roughened externally, and crusted with selenite crystals, produced apparently by the action of acidulous waters on the shell itself."

"A short distance below the *Ostrea* bed, is a zone containing many large concretionary nodules. In some places, a horizontal surface of this bed has been exposed, forming an arid wind-blown expanse of crumpled fragments of the shale, which here and there supports an *Artemisia*, and from which the nodular masses stand up at intervals, as they have been exposed by weathering. The concretions are often as much as twelve or fifteen feet in diameter, and lenticular in form, but are generally broken into fragments by the action of the frost. They hold remains of *Ammonites* and *Baculites*, the former at times two feet in diameter, and referable to *A. placenta*, a form, like *Ostrea patina*, characteristic of the 4th group of the Missouri River section. The fossils are unfortunately intersected by the cracks which traverse the mass of the nodules, in such a way as to render their preservation very difficult. Some of them retain their nacreous lustre in all its original perfection. Bleached bands like those already described, occur in many parts of these clays.

"The beds here appear to be perfectly horizontal, and the increased elevation of the general surface of the country will more than suffice to account for the re-appearance of the yellow sandy deposits last seen in the Bad Lands—without supposing the existence of any gentle anticlinal between the two localities. Our camp, situated a short way down the eastern slope of the White Mud valley, and consequently somewhat below the general level of the prairie, was 445 feet above the Wood Mountain astronomical station, nineteen miles east, by comparison of seven barometric readings at each place. The base of the yellow sands being about 30 feet below the camp, is 409 feet above the astronomical station; and as the base of the same stratum (division γ) in the Bad Lands section, was found to be about 170 feet above the astronomical

Easterly dip.

station, a difference of 239 feet between the same horizon in the Bad Lands and at White Mud River, would remain in favor of the latter. The distance being about thirty miles, gives an eastward slope of about eight feet in the mile."

PLAINS NORTH OF THE CYPRESS HILLS.

These plains are partly based on the Belly River series, and partly on the Pierre, but are usually covered so deeply with boulder-clay and other deposits of glacial age, that exposures of the older rocks are seldom seen. The junction of these two formations can be traced with some precision from Bull's Head plateau to near Forbes on the line of the Canadian Pacific railway, but north of that point, it is not again seen until the Saskatchewan River is reached.

At Bull's Head plateau, Ross' Creek near Irvine station, C. P. R. and a number of intervening points, the superposition of the Pierre on the Belly River series is clearly shown. North of Irvine, characteristic exposures of Pierre holding large calcareous nodules occur, and a thin covering of these rocks may extend north to the Saskatchewan, and connect with the band of dark shales which was observed capping the banks there in one place.

A feature of this plain is the number of old water-courses which are found in different parts of it. One of the most remarkable of these commences at Medicine Hat and runs east for over thirty miles, then bends to the north, and continues on into Many Island Lake. At the bend, it is several miles wide, and encloses four small plateaus, which were probably islands at one time. In its lower part, this valley is now followed by Ross Creek, and in its upper part, by Stony Creek, Mackay Creek, and other streams flowing into Many Island Lake. From Many Island Lake, an old channel, which may be an extension of the same system, leads into Bitter Lake and then on to Big Stick Lake. South of Medicine Hat, Big Plume Creek is connected with a branch of Seven Persons River by a wide valley, which seems to be newer than the one now followed by the stream, as its banks are scarped and show extensive exposures of rocks belonging to the Belly River series, while in the present valley the older rocks are entirely concealed by drift.

Sand-hills.

The sand-hills, which cover such a large part of these plains, belong to the upper part of the glacial deposits. They are usually well stratified where undisturbed by the wind. Their material was probably derived from the Fox Hill, and the kindred sandy beds intercalated in the Pierre.

Relations of
Pierre and
Belly River
series

Old water-
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SECTION ON THE SOUTH SASKATCHEWAN, NORTH AND EAST OF
MEDICINE HAT.

At Medicine Hat, the valley of the Saskatchewan enters, and traverses drift-filled depressions, for some distance one of those drift-filled depressions, which so constantly interrupt the sections on all the principal streams. The entrance of a stream into one of these old basins, is indicated at once by the increased width of its valley, as well as by the absence of all exposures of the older rocks. The Saskatchewan west of Medicine Hat is somewhat closely confined by steep rocky banks which force it to follow a comparatively direct course, but east of that point it becomes much more tortuous and continues so until it crosses the pre-glacial hollow. This hollow, which may represent either a portion of the buried channel of some ancient river, or more probably, a lake basin, is of small extent, as going in a northeasterly direction from Medicine Hat, the underlying rocks appear near the bottom of the valley in about eight miles, though they do not rise to any height in the banks for eight or ten miles farther. In a southerly direction up Big Plume Creek the edge of the basin is reached in seven miles, and in an easterly direction up Ross Creek in about fifteen. Its extent in other directions could not be ascertained.

The deposits in this basin are partly glacial and partly pre-glacial. Deposits in The pre-glacial deposits consist of pebble conglomerate, coarse ferruginous sands filled with small pebbles, silts, and sands, and are very similar in lithological composition and in appearance to the Miocene rocks of the Cypress Hills, from which they were without doubt derived. They are probably of Pliocene age.

The glacial deposits, which consist of light yellowish boulder-clay, overlaid in some places by thick sandy beds, have been extensive enough to complete the obliteration of the depression. The boulder-clay is well exposed near the bend of the river, and up the valleys of Ross Creek and Big Plume Creek for several miles from their mouths. In some places it shows obscure lines of stratification.

The rocks of the Belly River series which disappear below the Pliocene at Medicine Hat, re-appear about seven miles further down. The exposure consists of dark arenaceous shales overlying greyish sands and sandstone, and underlying unconformably the sands and gravels of the Pliocene. A few miles farther down, the same beds enclose a small coal seam. This seam occurs at the same horizon and is probably a continuation of the seam mined above Medicine Hat. (See Report of Progress 1882-84, p. 77 c.) It is seen at several places between Medicine Hat and Drowning Man's Ford. The most promising exposure occurs about a mile north of the southern boundary of Township

16, Range V, west of the 3rd Principal Meridian; at this point it is about five feet thick, but the quality is very inferior. Between this exposure and Drowning Man's Ford, the section exhibits nothing worthy of much attention. The Belly River rocks undulate near the surface, sometimes rising fifty or a hundred feet above the water-level and then gradually declining until they disappear altogether and for some distance boulder-clay alone with its accompanying beds of silt and sand, appears in the banks.

Wide valley.

Change in character of valley

Canyon.

Pre-glacial ridge.

Description of Belly River series

Dark shales

Yellower beds.

At Drowning Man's Ford, the valley becomes much lower, and receives from the west a wide shallow and at present little used valley. I was unable to trace this valley up, owing to lack of time. Its existence may be connected with the fact that immediately north of it the river-valley bends away to the east and assumes a much more recent appearance, and it is possible that it may represent a former channel of the river. The character of the valley, after bending east from Drowning Man's Ford, undergoes a marked change; it narrows in to about half its former width, and is confined by bold mural banks often over 500 feet high, which almost seem to overhang the stream. The next thirty miles affords a number of very picturesque views. The cañon is caused by a wide ridge of rocks belonging to the Belly River series which the river encounters and through which it has cut a passage. This ridge, which must have formed a conspicuous feature in the topography of the country in pre-glacial times, has been concealed by the general levelling up to which the country was subjected during the glacial period. It runs north to the Red Deer, which it crosses about twenty miles from its mouth.

The rocks shown in the cañon belong to the upper part of the Belly River series, and consist of pure clays and sands, together with all gradations between the two. They are extremely irregular and no section measured at one place would be applicable anywhere else. In addition to the soft sands and clays, hard beds of greyish and yellowish sandstones are of common occurrence, and more infrequently bands of brown carbonaceous shales, and thin ironstone beds. The sandstones are often nodular, and the coarser varieties frequently exhibit false bedding. The color of the whole section is predominantly grey, but yellowish and brownish tints occasionally prevail, especially towards the top. About four miles below the Rapid Narrows the section is capped by fifty feet of dark shales which may belong to the lower part of the Pierre. These shales continue for three or four miles and then disappear as the banks become lower. For the next twenty miles sections of the Belly River series are almost continuous on both sides of the river, and are exactly similar to those further up, except in evincing a tendency to become somewhat more yellowish in colour.

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They are usually covered by a considerable thickness of boulder-clay and stratified sands. At one point, opposite the Middle Sand Hills, the western bank is covered for some distance by a thick bed of blown sand. Near Sandy Point, the beds of the Belly River series become greatly decreased in height in the banks, and are overlaid by 200 feet of yellowish sandy clays and stratified sands representing the glacial deposits. A few miles east of Sandy Point, the western edge of a second pre-glacial basin.
Pre-glacial basin.

The following section, which was measured about eight miles west of the mouth of the Red Deer, shows the character of the beds occurring in it:—

	FEET.
1. Fine grained sands and silts.....	65
2. Boulder-clay	10
3. Stratified sands and silts.....	150
4. Unconsolidated gravel.....	2
5. Belly River series.....	175
	402

The gravel bed is more attenuated than is usually the case, but is Gravel bed very persistent and was found wherever the base of the deposit was seen. The sands and silts overlying it are very similar in appearance and composition to the fine grained strata forming the upper part of the Laramie in the Cypress Hills. They are yellowish in color and are usually well stratified. No fossils of any kind were found in them, No fossils although they were carefully searched especially on that account, and the position in the later Pliocene to which they have been provisionally assigned, has been given them simply on the strength of their stratigraphical relations. The boulder-clay at this point is of the usual character, but is capped with a somewhat peculiar bed of thinly laminated shale. Laminated shale.

A few miles above the mouth of the Red Deer, the Belly River series, Disappearance of Belly River series. which have been almost continuously exposed for the preceding seventy-five miles, gradually descend to and then disappear below the surface of the river. The following fossils were obtained from one of the last exposures:—*Physa Copei*, *Unio consuetus*, *Anodonta propatoris*, *Mytilus subarcuatus*. At the Forks, the upper beds of the Pliocene Pliocene appear near the water level at a number of places, but the greater part of the section is occupied by the boulder-clay, and for the next sixty miles no exposures of any older rocks occur. The break in the section Break in section. may be due, either to the stream having now regained a former channel, or to its entrance into a pre-glacial basin which has since been filled with Pliocene and glacial deposits. The width of the hollow could not be ascertained, owing to the absence of tributary valleys of

Exposures of
Belly River
series.

Fossils

Pierre
escarpment.

Strange
appearance
of banks.

Land-slips

Pierre more
arenaceous

any size. The valley of the Saskatchewan east of the mouth of the Red Deer, is seldom less than two miles wide, and is characterized by wide bottoms and easy grass-grown slopes. It affords no geological information of any importance until within a few miles of Antelope Creek, at which point a few small exposures of Belly River sands and clays, were found, scattered at intervals along the bank. These sections, especially towards the top, contain a larger proportion of soft sands and sandstones than is usually the case with this series, and the bright yellowish color of many of the upper beds, gives them a very different appearance, from the almost colorless strata occupying a similar position in the Bow and Belly Rivers country. A number of fossils were obtained from a hard sandstone bed contained in one of the sections. The Pliocene deposits which covered the formation when it sank below the surface west of the mouth of the Red Deer, have disappeared and it is now directly overlaid by the boulder-clay.

A few miles farther down, the river is crossed by what is practically a continuation of the northern escarpment of the Cypress Hills plateau, and its valley becomes at once greatly enlarged. The escarpment is built of Pierre shale, exposures of which, commencing at this point, are of constant occurrence all the way down to the Elbow and beyond. The valley continues to be very deep and wide until it reaches the eastern edge of the Côteau after which it becomes much shallower. Its banks, west of the Côteau, present a somewhat strange appearance, due to the way in which the slope is interrupted by a quick succession of irregularly distributed conical hills, the tops of which are usually black and bare. These hills, which completely cover the surface in many places, are in most cases the results of old land-slips, which have been smoothed and rounded by the action of the atmosphere. Their outline is occasionally broken by small terraces, caused by the superior hardness of some of the beds and by lines of ironstone nodules.

The shales and associated sandy beds have been so confused, and their relative position so often reversed by the frequent repetition of these slides, that it is almost impossible, notwithstanding the great extent of the exposures, to obtain an accurate section of any thickness. A sufficient number of partial sections was obtained, however, to show that the formation, in this district, is much more arenaceous than usual, and that the shales alternate throughout with thick beds of yellowish sandstone. The following sections which occur near the middle of the formation, will serve to illustrate this fact. It was measured opposite Swift Current Creek, and is in descending order:—

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	FEET.
1. Dark brownish shales.....	20
2. Yellowish and greyish sands, becoming argillaceous near bottom.....	50
3. Brownish shales, surface covered with crystals of selenite.	50
4. Yellowish ferruginous sands and sandstone, filled with large ironstone nodules.....	50
	—
	170

The sandstone bands in this section are filled with fossils, and fossils yielded the following amongst numerous others:—*Placenticeras placenta*, *Baculites grandis*, *Haminea occidentalis*, *Liopista undata*, *Protocardia subquadrata* et *borealis*. *Cyprina ovata*, *Yoldia Evansi*, *Inoceramus Sayensis* var. *Nebrascensis*, *Gervilia recta*, *Pteria linguiformis* et *Nebrascuna*. A number of these fossils have been described as Fox Hill, Fossils by Meek, and the fact of their being found here towards the base of the Pierre, together with the occurrence of so-called Laramie fossils in beds which are indisputably sub-Pierre, show, that owing to the wide range of many of the species, little dependance can be placed on the determination of the sub-divisions of the Cretaceous on purely palaeontological grounds, at least, in the absence of a full suite of fossils.

East of the the Côteau the banks of the valley decrease in height, but continue to show occasional exposures of Pierre, as far as the Elbow, where my examination ended.

THE CÔTEAU.

The Côteau constitutes one of the most important topographical features of the central plains. It corresponds with the eastern edge of the third prairie steppe, and is marked by a well defined and permanent rise of several hundred feet in the general increase in elevation of the country to the west. It crosses the boundary in longitude 103° Trend of Côteau W. of Greenwich, and then runs in an irregular but unbroken line north-easterly to the South Saskatchewan, which it reaches about thirty miles above the Elbow. The gap, where it is broken through by the river, is about twelve miles wide. Between the north and south branches of the Saskatchewan it is divided up by transverse coulees into several plateaus. At the boundary, the ascent is long and gradual, ^{Gradual slope at boundary.} and scarcely exceeds 200 feet, but there the drift deposits seem to have been piled on the eastern slope, and not on the summit of the Laramie plateau, as is the case further north. At the Dirt Hills, which are situated about half-way between the boundary and the Saskatchewan, the escarpment becomes more abrupt, and has a height, Height according to Dr. Bell, of over 600 feet. North, towards the Saskatchewan,

Height of
plains at base.

wan, the height decreases again, and at Secretan, on the line of the Canadian Pacific railway, is only 300 feet. The plains, along the base of the Côteau, maintain a general height of about 1,950 feet, from the boundary north, in consequence of the northern declination of the country being almost evenly balanced by the increased elevation due to the western trend of the escarpment.

Composition.

The Côteau is not dependent for its existence on any particular formation; as the Pierre Fox Hill and Laramie, as well as the glacial deposits, all enter into its composition. At the boundary it consists entirely of Laramie, overlaid by drift, but going north, the Cretaceous appears at its base near the Dirt Hills, and then gradually rises in the escarpment, and near the Saskatchewan, forms almost, if not the whole of its substance. North of the Dirt Hills, the older rocks are usually covered with drift, and in the part laid down on the map which accompanies this report, only three small exposures of Laramie were found. The limits of this formation, had, therefore, for the most part, to be traced out by differences in elevation and are only approximate, as it is possible that depressions cutting through it, may have existed, which have since been levelled up by the drift. A couple of small exposures were found in the eastern edge of the Vermilion Hills, and north of the river a small detached plateau afforded a section, showing the Cretaceous clays and sands, overlaid by a hundred feet of white argillaceous indurated sands, or soft sandstone, exactly similar to the lower part of the Laramie in Wood Mountain. A small exposure was found south of the Moosejaw and Wood Mountain trail and outside the limits of the map, which is important, as it shews that some, at least, of the kame-like hills and ridges which crown the Côteau, owe their shape, not to accumulations of drift, but to irregularities in the surface of the older rocks. The exposure consisted of light-coloured clays and sands, and was found in the side of a small hill which had the usual aspect of those of the Côteau, and was situated near the highest part of the ridge.

Exposures infrequent.

Important
exposures.

Drift deposits.

The Côteau an
old sea margin.

The drift deposits are poorly exposed in that part of the Côteau examined by me, and seem to consist simply of boulder-clay overlaid by irregularly stratified sands and gravels. The deposits are not distributed uniformly, but thin out in the direction of the plateau like that between the South end of the Côteau and the Dirt Hills.

That the Côteau formed the margin of an ancient sea, is rendered highly probably by its extent and uniformity, its independent course, and the generally even height of the plains along its base, although all direct evidences of the fact, such as terraces and raised beaches have long since necessarily disappeared, and have been either destroyed by denudation or buried under the drift.

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The Eyebrow Hills, which are situated near the head waters of the Eyebrow Hills, Qu'Appelle, may be regarded as an outlier of the Côteau. They project about 100 feet above the undulating plains around them, and are composed of the arenaceous upper part of the Pierre or Fox Hill. They are sand-hills, covered in one place by small sand-hills, the material of which has been obtained directly from a disintegrating bed of soft sandstone, which is plainly exposed to view. The drift deposits on these hills are very thin, and are represented in some places by a few scattered boulders only, a somewhat remarkable circumstance, in view of the fact, that the hills have been selected by a prominent glacialist, as one of the resting places of his continental glacier. The drift deposits also become very thin over parts of the plain lying between the Eyebrow Hills and the foot of the Côteau; and at one place along Thunder Creek, the surface was observed to be underlaid for some little distance by the Cretaceous clays. It is possible, however, that in this and in similar cases, the drift may have been removed by denudation. East of the Eyebrow Hills, an escarpment about 200 feet high, faces eastward and runs for some distance parallel with the Qu'Appelle valley.

Drift deposits.

GENERAL GEOLOGY.

The following table includes all the formations observed in the district:—

Quaternary	- - -	Stratified sands and gravels. Silts. Boulder clay.
Tertiary	- - -	Pliocene (?) South Saskatchewan gravels. Miocene.
Cretaceous	- - -	Laramie. Fox Hill. Pierre. Belly River series.

BELLY RIVER SERIES.

The Belly River series is represented by its light-colored upper division which is distributed over a large area in the north-western and south-western parts of the district. It is well shown in the cañon-like part of the Saskatchewan between Medicine Hat and the mouth of the Red Deer, where almost complete sections can be obtained, and also in the valleys of Milk River and Many Berries Creek, and at Bull's Head plateau, Ross Creek, and numerous other places along its eastern boundary.

Character.

The general character of the formation is remarkably constant, although individual beds are subject to rapid changes in composition and texture, and the following description of the formation, as observed in the Bow and Belly Rivers district by Dr. G. M. Dawson, is equally applicable here. (Report of Progress, 1882-84, page 116 c.)

"It is composed for the most part of sandy clays, with shales and sandstone, the latter often of considerable thickness, and usually rather soft or irregularly hardened. Layers of ironstone nodules, which are at times very large, are of frequent occurrence, and the beds generally have a characteristic bluish- or greenish-grey tint, and are, on the whole, rather massive and weather easily into bad-lands. In these features, with the occurrence of rolled clay pellets and the rounded character of many of the included bones, there is evidence of a considerable amount of current or wave action."

In addition to the varieties mentioned above, beds of yellowish nodular sandstone attain considerable importance in some of the sections, and are frequently found capping the formation. The distinctive pale color which is so characteristic of the series as a whole from Medicine Hat west, is replaced towards the north-east, to some extent at least, by more yellowish tints. The change was first noticed in the sections around the Rapid Narrows on the Saskatchewan, but becomes more evident farther down the river.

Stratigraphical position.

The doubt which existed at one time in regard to the stratigraphical position of the Belly River series, on account of the Laramie *fauna*, its invertebrate fauna, has been removed by a more complete examination of its eastern margin. Its line of contact with the Pierre has now been traced, through a distance of over 150 miles, by numerous exposures, all of which afforded the clearest possible proof of its subordinate position. The junction is marked in many places by low plateaus (see p. 41), which offer exceptional facilities for noting the relations of the two formations, as they owe their origin directly to the superposition of a protecting covering of the less easily eroded dark shales on the light-colored beds below. The western slopes of these plateaus are usually bare, and the line of contact between the two similarly colored series distinctly drawn. A reference to the general section which accompanies the map will also show that at the west end of the Cypress Hills, the Laramie and Belly River series separated by the Pierre shales, occur in what is practically the same section, and as the beds have been so little disturbed, that their maximum dip seldom exceeds ten feet to the mile, and consequently no question of overturn or dislocation is involved, no better stratigraphical evidence can possibly be offered.

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FIGURE 1.—CROSS SECTION OF THE CANNON CANYON FAULT WAY.

From *Bull. Amer. Geol. Soc.* 1904.

Locality: Cannon River, N.E. 1/4 sec. 10, R. 10 E., Minnehaha Co., Minn.

Scale: 1/2 mile. The distance between the two points shown is about 1/2 mile.

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In a couple of places south of the "Gap," along the valley which connects Cypress Lake with the East Fork of Milk River, some small areas of conglomerate were found, which are probably of the same age as the incoherent gravels and conglomerates found in so many places, beneath the drift, in the valleys of the larger streams (compare Report of Progress, 1882-84, p. 140, c.).

SWIFT CURRENT CREEK PLATEAU.

Swift Current Creek plateau is a low diffuse ridge, situated north-east from that of the Cypress Hills and separated from it by a shallow depression about twelve miles wide. It is about forty-five miles long and twenty wide, and has an elevation of four to five hundred feet above the plains around it, or 2,330 feet above the sea. Its surface is usually undulating, but in some places becomes very hilly, and its edges show comparatively easy slopes, and nowhere present the abrupt escarpments so characteristic of Wood Mountain and the Cypress Hills. It is drained on the north by Swift Current Creek, which runs through the plateau for some miles, and on the south by the different branches of Old Wives Creek. A deep valley has been cut completely across it, by a branch of the former stream incising with one from the latter.

The easy slopes of this plateau, the grass-covered condition of most of its valleys, and the consequent absence of any extensive exposures, renders the collection of details in regard to its geological structure a task of some difficulty. Its main features, however, are simple and easily understood. Two formations only enter into its composition, viz: the upper part of the Pierre shales and a deposit similar in composition to the Miocene rocks of the Cypress Hills. The latter formation, which is referred to the Miocene, rests unconformably on the Pierre; the Fox Hill and Laramie being usually absent. This plateau suffered more severely from the effects of denudation previous to the deposition of the Miocene than the Cypress Hills, as not only have the Fox Hill and Laramie been almost entirely swept away, but part of the Pierre also has disappeared.

The Pierre shales, in the north-eastern part of this plateau, present Pierre shales. a somewhat strange appearance to one accustomed to their dark tints elsewhere, as here at a distance they look almost white. The lightness of the color, is, however, partly due to bleaching, as in a fresh exposure, light-grey and bluish tints prevail. The difference in color, is accompanied by a corresponding change in composition, as they have become more arenaceous, and in places pass into a soft sandstone. The foliation is also unusually coarse, and the different beds often exhibit slight differences in color due to their more or less arenaceous

Newer conglomates.

Swift Current Creek plateau.

Composition.

Change in color
and composition.

character. The faces of some of the sections are studded with large arenaceous nodules, which are frequently incrusted with radiating crystals of selenite. Shales answering to the above description are exposed in a number of sections along Rush Lake Creek, and some of its branches, and are there usually overlaid by a heavy bed of conglomerate.

Shales darker.

A few miles further west, on Swift Current Creek, where the shales are next met with, they are darker in color, but are still very arenaceous, and it is possible that some of the upper beds may represent part of the Fox Hill.

Exposures of shales.

The Pierre shales, with the exception of a short interruption after the stream enters the plateau country, are exposed along the whole length of Swift Current Creek, from the Cypress Hills to the Saskatchewan, the fall of the stream being almost identical with the dip of the formation. They are also exposed in a number of places along the southern and eastern edges of the plateau, in the valleys of the different branches of Old Wives Creek. One of the exposures near the south-eastern edge of the plateau in Township 10, Range xi., west of the 4th Principal Meridian, yielded a number of fossils, amongst which are:—*Yoldia Evansi*, *Lucina occidentalis*, *Newria Moreauensis*, *Acteon attenuatus*, *Anisomyon centrale*, *Anchura Americana*, *Syrphites Nicollaei*, *Syphophites Subglobosus*.

Pierre overlaid by Miocene.

The Pierre shales are usually overlaid unconformably by the Miocene. At one point near the north-eastern edge of the plateau an exposure of yellowish and greyish sands and silts, and greyish and dark clays was observed, which may possibly belong to the Laramie, and coarse yellowish sandstones, resembling the Fox Hill, were seen in a couple of places; but in most cases, these formations are absent, and the Miocene rests directly on the dark argillaceous clays of the Pierre.

Miocene.

Best exposures.

The Miocene deposits of Swift Current Creek' plateau, while resembling in a general way, the corresponding rocks in the Cypress Hills differ from them in containing a smaller proportion of pebble conglomerate, and in the superior hardness of some of the sandstone beds. The best exposures are found in the valley, noted previously as crossing the plateau transversely, the banks of which afford a broken section of about 300 feet. This section was too fragmentary to admit of any detailed measurements, but the rocks exhibited in it may be generally described as consisting of coarse false-bedded sandstone, with occasional beds of a harder finer-grained variety, usually greyish or light-yellowish in color, hard silicious sands, clays, shaly clays, marls and pebble conglomerates. The conglomerate usually forms a compact rock, the pebble being held together by a hard, calcareous cement, but in some places its constituents are very feebly consolidated, and occasionally

Conglomerate.

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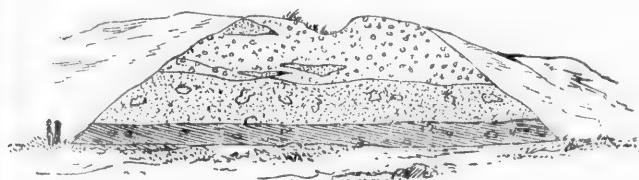
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they lie quite loose in the bed. The pebbles, which are always well-rounded, are formed of hard, light-coloured quartzites, and are probably like those of the Cypress Hills, derived from the Cambrian quartzites of the Rocky Mountains. In addition to the rocks mentioned above, beds of impure nodular limestone are of occasional occurrence. These beds, which are very characteristic of the Miocene, are only slightly indurated, and when subjected to the influence of the atmosphere, soon crumble away and cover the bank with small nodules, ranging in size up to about half an inch in diameter. The general section presents a somewhat greyish appearance at a distance, owing to the obtrusive whiteness of some of these calcareous beds, although most of them are found to be more or less yellowish on closer inspection. The conglomerates in this section, are not developed to nearly the same extent as in the corresponding sections in the Cypress Hills, a fact due, no doubt, to their greater distance from the mountains, but toward the outskirts of the deposit they become relatively much more important, and occasionally the whole formation is reduced to a single thick bed of this rock.

The Miocene sections on Swift Current Creek begin a few miles above the crossing of the Canadian Pacific railway with a single bed of conglomerate. Farther up, this bed becomes associated with irregular deposits of silts, sands and clays, which disappear again as the western boundary of the formation is approached. The sections on this stream are sufficiently well exposed to show that there is a small but well-defined dip towards the centre of the area, and that the Miocene occupies a shallow basin-shaped depression in the Pierre. This fact, taken in connection with the general irregular character of the deposits, the prevalence of false bedding, and the decreasing proportion of conglomerates towards the centre, show the formation to be of lacustrine origin, and it was probably deposited in a dilatation of some large river flowing eastward from the Rocky Mountains.



SECTION SHOWING MIocene BEDS SUPERPOSED ON PIERRE SHALES.

The exposures along the southern and eastern edges of the plateau are insignificant in extent, but are sufficient to define the boundary of the formation in a general way. One of these, which shows the junction of the Pierre and Miocene very well, is illustrated in the accompanying cut. It consists of fifteen feet of bluish, yellow-

Exposures
along southern
and eastern
edges.

weathering, fine-grained argillaceous sands holding calcareous nodules, resting on the Pierre and underlying about fifteen feet of pebble conglomerate. In this section, small beds of sand are enclosed in the conglomerate.

Bed of conglomerate.

Fossils.

Drift.

On Rush Lake Creek, the Pierre is overlaid by a single thick bed of conglomerate, the extent and relations of which could not be very well worked out, owing to the infrequency of exposures, but which probably post-dates the Miocene in age.

The only fossils which I succeeded in finding in the Miocene of this plateau were a few indeterminable fragments of the remains of vertebrate animals. Invertebrate fossils seem to be entirely absent.

There are a few Laurentian boulders scattered over Swift Current Creek plateau, but otherwise, except on its northern boundary, it is entirely driftless. This fact is of some importance in tracing out the Miocene, as its junction with the Pierre can be defined approximately by noticing the difference in the materials brought up by burrowing animals; the light-colored calcareous débris brought up by animals burrowing into the Miocene being different from that seen when the surface is underlaid by Pierre or boulder-clay.

GEOLOGY OF THE COUNTRY SOUTH OF THE CYPRESS HILLS.

The rocks underlying the surface of the country in the south-western corner of the map are well exposed in the almost precipitous and scarped banks of the valley of Milk River, and also a little farther north in the valley of Many Berries Creek, the outlet of Lake Pakow-ki. These two streams occupy valleys from 200 to 300 feet in depth, and from a mile to a mile and a half in width, the banks of which afford magnificent sections of the rocks belonging to the Belly River series, into which formation they are cut.

Milk River valley was visited and examined by Dr. G. M. Dawson in 1874, while connected with H.M. North American Boundary Commission Survey, and the following detailed description is quoted from him:—*

Milk River valley.

"The valley of the Milk River is one of the most important features met with on the line of the forty-ninth parallel, and offers continuous and magnificent sections of beds referable to the Lignite Tertiary series. The country on both sides of it is seamed with tributary ravines and gorges, the banks of which are often nearly perpendicular, and which ramify in all directions. Where the Line crosses the river

* Geology and Resources of the Forty-ninth Parallel, 1875, p. 117. The quotation is given at length, as the volume is now out of print. The beds described were at the time supposed to be of "Lignite Tertiary" (Laramie) age. See Report of Progress, 1882-84, pp. 45 C-122 C.

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At the south-western boundary, it is
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one mile wide valley by burrowing
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south-western escarpments and little farther
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valley, it is utterly impassable for waggons or carts, and near this place the Great Dry Couleé branches off, which, according to Palliser's map, runs to Lake Pā-kow-ki. The appearance of the valley of the river itself is strange and desolate.

The banks rise nearly 300 feet above the level of the stream, and are more than a mile apart. They are almost bare of vegetation, and marked by bands of different colored clays and sandstones in a nearly horizontal position, as far as the eye can reach. The descent into the valley cannot be made on horseback but by taking advantage of the well-worn buffalo tracks, which are found leading down almost every coulée and ravine. The river itself is comparatively insignificant, and winds in broad curves from side to side of the valley, and is fringed by a grove of large poplar trees, and by willows. The bottom of the valley is marked out into three distinct levels, differing much in appearance, though only by a few feet in height. Over the first of these the river must constantly pass in flood. It shows in many places a luxuriant growth of grass, and supports most of the timber. The second level, which the river can seldom if ever touch, is characterized by the abundant growth of *Artemisia* of several different species. The third level, which forms a kind of low terrace at the foot of the hills, and must be twenty to thirty feet above the stream, consists of parched clay, the washings of the banks, and nourishes only a few other thick-leaved drought-loving plants.

The sections on the banks are undisturbed and regular. The beds are divided into an upper and lower series, by a zone of sandstones, which is about two-thirds up the bank near the Line, but about eight miles north-westward up the valley, is found forming the very summit of the cliff; which here, from the better support afforded by such hard rock as compared with the clays and arenaceous clays of the rest of the elevation, assumes a bolder and more rugged aspect, and a greater height than elsewhere. Fourteen miles south-eastward of the crossing of the Line, the same sandstone zone is again seen, but now only about half way up the bank, indicating a general inclination of the beds in a south-easterly direction—which may not be exactly that of the full cliff—of about ten feet to a mile.

The sandstones, though often well and evenly bedded, are not generally hardened, but have a nodular character, and though in some localities indurated throughout their entire thickness, in other places when removed, they may show only certain hard layers of comparatively small thickness, separated by beds of unconsolidated sand. They appear, however, to be very constant in extent, and do not differ materially in thickness at the several localities where they were examined. They are slightly ferruginous, with prevailing light yellow tints, and are often more or less affected by false bedding.

Sandstones.

Rocks below
sandstones.

" Below the sandstones occur clays, sands, and arenaceous clays generally well stratified, and individual beds of which may often be traced a long way up or down the valley. The colors are usually light but there are some zones of darker carbonaceous clays, and in a few places impure lignites of no great thickness were observed. These appeared to be less persistent than most of the other beds, and generally to thin out and disappear when followed far in either direction. From their appearance, and mode of occurrence, these lignites may well have originated from the drifting together of wood or peaty matter, and differ considerably from the pure and definite beds which characterize the Lignite Tertiary further east, and which appear to have formed of trees which have grown on the spot.

" Above the sandstone zone is a great thickness of sands and arenaceous clays, forming more massive beds, in which the stratification is less perfectly marked. The general tints are pale greenish-grey, greyish, and light buff.

Fossils.

" No fossils were found in this upper series or in the sandstones, but the beds below the sandstones, organic remains are also singularly rare, but are not altogether absent. In a part of the section not far below the base of the sandstone zone, is a layer with great arenaceous concretions, which contain in some places abundance of fossils."

Amongst these are *Campeloma productum*, one or more species of *Vicipara*, two species of *Corbula*, a *Helix*, and *Sphaerium formosum*, var. *

Vertebrate
remains.

" A few rolled fragments of bones are also included in the bed, and some traces of fossil plants. Lower down in the section valves of *Ostrea* are found, sparingly scattered through the deposit, and not very far from the base, a layer containing shells of *Unio* in a poor state of preservation was observed. Near the latter were found fragments of the bones of a large vertebrate. They were scattered, and not in a very good state of preservation, and had evidently been strewn about after the death of the animal, and before their envelopment by the sediment. These, with the other vertebrate remains, were submitted to Prof. Cope, who pronounced them to be portions of the sacrum and long-bones of a Dinosaurian.

" A section of the upper beds and sandstones, observed in a ravine on the east side of the Great Dry Coulée, near the Line, showed the following succession of beds:—

* The names of fossil molluscs here given have been revised by Mr. Whiteaves in conformity with his later researches.

FEET. INCHES.

1. Light yellowish arenaceous clays and sands, indicated in slopes and higher grounds, but of which a few feet at the base only are well exposed	6	8
2. Grey sand	4	5
3. Grey-green arenaceous clay	9	0
4. Arenaceous clay (rusty, irregular layer).....	2	3
5. Highly ferruginous layer. A few inches.		
6. Grey arenaceous clay, rather conspicuously banded....	17	10
7. Grey soft sandstone	14	5
8. Sandstones, hard and soft, brownish, yellowish and grey; often concretionary, generally well stratified, but sometimes false-bedded, forming cliffs in the gorge, and weathering out into overhanging ledges, and horizontally fluted walls.....	35	6
About.....	90	0

"The most complete section of the beds below the sandstone zone ^{Most complete}_{section.} was obtained about eight miles north-westward from the intersection of the valley with the Line, and on the north-east side of the valley. It may overlap the last by a few feet, or a few feet may be omitted; but, allowing for this slight uncertainty, it forms a continuation downward of the base of the former section.

FEET. INCHES.

1. Soft grey sandstone, forming the top of the bank (about).....	4	6
2. Red-brown concretionary sandstone, with large flattened nodules.....	4	6
3. Hard grey sand	4	5
4. Reddish nodular sandstone.....	2	0
5. Whitish arenaceous clays, with some selenite in the lower layers.....	22	6
6. Greyish and yellowish arenaceous clays (banded) ..	13	4
7. Yellow-grey arenaceous clay.....	11	0
8. Greyish arenaceous clay in which stratification is scarcely apparent	71	4
9. Yellowish sandstone, thin bedded.....	2	0
10. Grey arenaceous clay.....	4	5
11. Purplish shale	1	6
12. Grey arenaceous clay.....	5	6
13. Brown shale, with imperfectly preserved plant remains.....	0	6
14. Grey arenaceous clay	14	8
15. Purplish shale, with some thin layers of impure lignite.....	8	10
16. Purplish-brown shale	1	0
17. Greyish arenaceous clay	7	7
18. Grey arenaceous clay, upper part shaly	11	1

	FEET. INCHES.
19. Yellowish arenaceous clay	4 5
20. Purplish shale	1 0
21. Yellowish arenaceous clay	8 11
22. Purplish shale	2 2
23. Greyish arenaceous clay	6 9
24. Sandstone, a few inches.	
25. Greyish arenaceous clay	4 6
26. Yellowish arenaceous clay (lowest bed in which remains of molluscs were found at this place. <i>Ostrea</i>)	4 5
27. Nodularly hardened sandstone	1 0
28. Yellowish arenaceous clay	31 0
Concealed in slope to river, about	30 0
About	284 10

Thickness.

"The thickness of beds displayed in the above sections, when combined, is about 375 feet, and the bottom of the river-valley is, probably not very far above the base of the Lignite Tertiary formation. It will be observed that the genus *Ostrea*, is here for the first time mentioned as occurring in these beds; further west it becomes one of the most usual forms. The conditions of deposit implied by the beds on the Milk River, are those of an estuary, or shallow sea margin, where, while oysters and corbulas were living, the remains of fresh-water shells and land vegetation, were being carried and mingled with them."

"The superposition of these beds on the Cretaceous clays of group 4, is not clear in this locality, as no junction of the two formations was observed. Their lithological character, might almost seem to render it probable, that they represent the same series as that supposed to come up from below the Cretaceous clays between the East and West Forks of Milk River."

Supposition confirmed.

This latter supposition has been confirmed by the work done since the above description was written, as the rocks shown in the valley of Milk River have been traced northward to Many Berries Creek, and from thence on to the head waters of Sage Creek, at which point they are plainly seen to be overlaid by the Fort Pierre shales.

Elevation of Plains.

The plains between Milk River and Many Berries Creek, near the international boundary, have a height of about 2,900 feet, but going north towards the south-west corner of the Cypress Hills, the elevation rapidly increases, and near the base of the hills it exceeds 4,000 feet. A few miles north of Many Berries Creek, proceeding in a northerly direction, the edge of a low plateau running north-west and south-east is reached. This plateau had been deeply gashed in many places along its south-western slope by coulees running back from Many Berries Creek and cutting deeply into the soft argillaceous and arenaceous

Low plateau.

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ocks of the Belly River series, which constitute its principal mass. Near the summit of the plateau, at an elevation of about 3,000 feet the Belly River series is overlaid by the Pierre shales. The superposition of the Pierre on the Belly River series is clearly seen in many of the sections along the edge of the plateau, especially on those occurring on the branches of Sage Creek. This stream heads in the Sage Creek, plateau, in which its numerous branches have carved out a deep bay, and flows south-eastward, crossing the forty-ninth parallel a few miles east of Wild Horse Lake. Near the Line, the banks are low and enclose a wide, desolate clay flat, on which nothing grows except sage-brush and cactus. Farther up, the banks of the valley become higher and sections of rock begin to appear. At one point, this stream has ^{Change in course of} been diverted from its old valley, probably by some obstruction during ^{stream.} the glacial age, which has turned it to the east, and it runs for several miles through a narrow valley, with steep-cut banks, before it regains its former channel. The newer valley was probably partly formed by incising coulees before it became the bed of the main stream. In its upper part Sage Creek divides up into a number of branches, all of which possess deep valleys and exhibit very fine sections of the rocks belonging to the upper part of the Belly River series and the basal portion of the Pierre shales. North of Sage Creek, the junction of the ^{Junction} Pierre and Belly River series is marked by a series of low plateaus ^{marked by low} plateaus, facing westward, and extending in a somewhat uneven line in a direction a little west of north to Bull's Head plateau, beyond which point they turn to the east.

The superposition of the Pierre shales, on the more arenaceous and ^{Superposition of Pierre on} lighter colored beds of the Belly River series, is unmistakably shown in ^{Belly River series.} a great number of places along the western slopes of this range of plateaus, and puts the question of the relative position of the two formations beyond doubt.

East of these plateaus, the Pierre shales become the surface formation, except where overlaid by the elevated Laramic plateaus, and continue so for a great distance; their easterly dip of about 10° to the mile, agreeing ^{Dip of shales.} very closely with the decline of the whole country in the same direction. Their presence is indicated by numerous exposures in the banks of all the principal valleys and also by the hard clayey and sterile nature of the soil, a feature which nearly always characterizes soils owing their origin to this formation.

The East and West Forks of Milk River afford good exposures of the shales in the upper parts of their courses, but near the boundary they become concealed by the heavy drift deposits. The drift is, however, almost entirely derived from the underlying shales, and it frequently contains clay-ironstone nodules, and also fragments of the more common fossils of the formation.

Belly River
series.

Heavy dip.

Interesting
section.

Section.

The rocks of the Belly River series are brought to the surface, and spread over a limited area, a few miles east of the West Fork in Township 1, Range xxvii, W. 3rd Principal Meridian. They are brought up quite suddenly by a heavy southerly dip from beneath the shales which they underlie conformably. This area was examined by Dr. G. M. Dawson, in 1874, and the following description is quoted from him.*

"A most interesting section occurs in a deep valley about six miles west of East Fork. Exactly on the Boundary-line, the banks show good exposures of the Cretaceous shales, more closely resembling in their lithological character those seen in the upper part of the Pembina Mountain sections, than those of the same beds as occurring in the vicinity of Wood Mountain. The rock is almost, or quite horizontal, is pretty hard, and well stratified, and includes white bands like those already referred to. On following the valley about a mile northward, these clay shales seem to bend suddenly upward and give place to a series of rocks, which appear to underlie them, and which differ from them altogether in character, and include massive layers of sandstone and thick arenaceous clays.

"A section was measured across the upturned edges of these beds, which is given below, the measurements being reduced, so as to represent the actual thickness of the strata. The section—supposing no reversal to have taken place—is in descending order:—

	FEET. INCHES.
1. Sombre Cretaceous clay-shales, Division 4, M. and H.	
2. Gray and yellow arenaceous clays, with some remains of <i>Ostrea</i> in the lower layers (about).....	20 0
3. Greyish-white arenaceous clay, with irregular sheets of ironstone	8 6
4. Carbonaceous shale.....	1 0
5. Grey arenaceous clay.....	2 6
6. Black carbonaceous shale	2 0
7. Dark shales, with carbonaceous bands.....	12 6
8. Carbonaceous shale, with poorly preserved plant remains.....	1 6
9. Grey arenaceous clay.....	30 0
10. Brown shale, with indistinct impressions of plants, a few inches.	
11. Grey arenaceous clay.....	3 6
12. Laminated carbonaceous shale, with spots of amber, and impressions of plants.....	2 0
13. Grey and yellow arenaceous clay.....	20 0
14. Yellowish arenaceous clay.....	11 0
15. Grey arenaceous clay	9 0

* Geology and Resources of the 49th Parallel, p. 114.

surface, and
work in Town
are brought
with the shales
mined by Dr.
Quinton from

about six miles
up stream show good
bedding in their
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tains—the vicinity
of the metal, is pretty
well exposed,
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series of rocks,
from altogether
about 100 feet thick arenaceous

of these beds,
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the thickness of the

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	FEET. INCHES.
10. Soft beds—probably yellowish arenaceous clays, but not well exposed.....	35 9
11. Grey sandstone, weathering yellow, and with many jointage-cracks.....	12 10
12. Greyish arenaceous clay.....	45 11
13. Hard sandstone, breaking into large rectangular fragments, and weathering into pot-holes.....	4 0
14. Soft arenaceous clays.....	12 10
15. Fine-grained grey-yellow sandstone, with dendritic markings.....	2 0
16. Grey and yellowish arenaceous clay, with some thin sheets of ironstone.....	31 5
17. Red-brown sandstone.....	2 0
18. Soft grey sandstone.....	6 5
19. Nodular brown sandstone.....	0 6
20. Soft beds, with some thin sandstone layers.....	24 0
21. Nodular red-brown sandstone, (about).....	3 0
22. Greyish and yellowish arenaceous clays, well stratified, and with small fragments of some Lamellibranchiate shell at the base.....	88 5
23. Greyish and yellowish arenaceous clays, well stratified.....	121 10
24. Sandstone.....	3 0
25. Brownish arenaceous clays, crumbling and rotten where exposed.....	134 4
26. Grey sandstone (Dip 45°).....	1 6
27. Yellowish sandstone, thin bedded and flaggy.....	34 0
28. Purplish and brownish clays, with evident stratification lines.....	47 7
29. Impure ironstone.....	1 0
30. Purplish shaly clays.....	127 3
31. Impure ironstone.....	1 0
32. Crumbling earthy clays.....	26 6
	893 7

"The beds below these are not exposed sufficiently well to enable the section to be measured. From blocks of sandstone strewing the banks, however, it is probable that one or more layers of this rock occur not far below the base, as here given.

"The strike of these beds is N. 27° E. (mag.) and their dip, south-east-ward, at angles varying from 45° to about 30°. The tilting of strata, to such angles as these—even if the existence of no more violent flexure be suspected—is in itself a circumstance sufficiently remarkable, in a country where, for hundreds of miles, the rocks are found with ^{Rocks seldom} _{much inclined.} inclinations no greater than can be accounted for by original irregularities of deposit. The nearest disturbed region is that in the neighbourhood of the Buttes, and the upturning is there in immediate connection with the extrusion of igneous matter."

Age of disturbed beds.

There is little doubt that the upper part, if not all of the beds brought up so unexpectedly in this place belong to the Belly River series. This is shown by their stratigraphical position, and also by their holding at one point numerous specimens of *Corbula perundata*, one of the most characteristic fossils of that formation. Some of the lower beds may belong to the same series as the lower dark shales found north of the Buttes on Milk River. The junction of the Belly River series and the Pierre shales along the southern edge of this disturbed area is clearly shown, but as the northern contact is concealed, it is impossible to say whether the presence of the underlying beds is due to a simple anticlinal swell, or if they are faulted along their northern border though the latter hypothesis seems the more probable one. In either case, the high angle at which these beds are is a quite anomalous occurrence in this district.

East Fork of Milk River.

The East Fork of Milk River after leaving the neighbourhood of the Cypress Hills, possesses little geological interest, as the insignificant sections seen along its valley show scarcely anything but drift. An exposure of Fox Hill sands was found at one point, near the extremity of a sharp bend which it makes to the east, about twenty miles north of the boundary.

Range of plateaus.

Proceeding in an easterly direction from this stream along a plain with an elevation of about 3,000 feet, the next point of interest which is reached is the range of low westward-facing plateaus, which extend from the boundary near Range xxiii., W. 3rd Principal Meridian in a north-westerly direction. Old-man-on-his-back plateau, the most northerly member of this range, is about four miles long and about 150 feet high. To the west it presents a steep scarped face, but in all other directions slopes gradually away. Its surface is undulating, and in its highest part very sparingly covered with drift. The beds which enter into the composition of this plateau, are well exposed on its western slope and are there seen to consist of about 300 feet of Pierre shales, capped by about 150 feet of yellowish Fox Hill sands and sandstone. A few thin beds of nodular sandstone near the top of the Fox Hill have served to arrest the work of denudation, and to preserve the plateau. A series of high rolling hills continues on from the plateau in an easterly direction for several miles. South-east of Old-man-on-his-back plateau, and separated from it by a wide valley, is a long rounded ridge, much lower than the plateaus either north or south of it, and composed entirely of Pierre. The third plateau, which extends to the eastward, is of more importance than the other two, as it re-introduces the Laramie with its accompanying carbonaceous zone. Good exposures occur along the western face of this plateau. The lowest beds seen consist of Pierre shales of the usual kind. Above these comes the Fox Hill

old-man-on-his-back plateau.

and the valley from Lang's Hill, which follows a north-westerly direction. Old-man-on-his-back plateau, the most northerly member of this range, is about four miles long and about 450 feet high. To the west it presents a steep scarped face, but in all other directions slopes gradually away. Its surface is undulating, and in its highest part very sparingly covered with drift. The beds which enter into the composition of this plateau, are well exposed on its western side.

Composition.

the composition of this plateau, are well exposed on its western slope and are there seen to consist of about 300 feet of Pierre shales, capped by about 150 feet of yellowish Fox Hill sands and sandstone. A few thin beds of nodular sandstone near the top of the Fox Hill have served to arrest the work of denudation, and to preserve the plateau. A series of high rolling hills continues on from the plateau in an easterly direction for several miles. South-east of Old-man-crags lies another plateau, and separated from it by a wide valley, is a long rounded ridge much lower than the plateaus either north or south of it, and called the *ridge of Pines*. The third plateau which extends to the eastward

Rounded ridge

plateau, and separated from it by a wide valley, is a long rounded ridge, much lower than the plateaus either north or south of it, and composed entirely of Pierre. The third plateau, which extends to the west, is of more importance than the other two, as it re-introduces the Laramie with its accompanying carbonaceous zone. Good exposures occur along the western face of this plateau. The lowest beds seen consist of Pierre shales of the usual kind. Above these comes the Fox Hill

Boundary plateau.

entirely of Pierre. The third plateau, which extends to the west, is of more importance than the other two, as it re-introduces the Laramie with its accompanying carbonaceous zone. Good exposures occur along the western face of this plateau. The lowest beds seen consist of Pierre shales of the usual kind. Above these comes the Fox Hill

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here about fifty feet. It is usually the sandstone in place. Laramie, the low white and grey c. lignite from two sets of fairly good coal-sites as the count *west* in a number of dark clay, and occupying a series of the Laramie coal-sites interstratified with fine-deposits, at the west occupying the Cypress Hills and *east* is undulating. The east and north exposures occur in depressions a couple of miles apart. It probably contains deposits of a similar character to the Hills, and in the valley the Pliocene. The state probably has been derived from the

East of this plateau affording no outlet for the River

Wood Mountain
Laramie area. Its
undisturbed and
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On approaching
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here about fifty feet thick. This formation looks a good deal greyer than is usually the case, and contains a considerable quantity of hard sandstone in places. The Fox Hill is succeeded conformably by the Laramie, the lower part of which consists of a conspicuous band of white and grey clays and sands, fifty-five feet thick, holding a seam of lignite from two to three feet in thickness. The lignite in this seam is of fairly good quality, and will become valuable for local purposes so soon as the country in its vicinity becomes settled. It has been burnt *situ* in a number of places along the escarpment. It is overlaid by a bed of dark clay, twenty feet thick, which looks exactly the same as a bed occupying a similar position in the Cypress Hills. The upper part of the Laramie consists of about fifty feet of yellowish and greyish beds interstratified with some thin beds of clay and sand. The Laramie deposits at this point bear a strong general resemblance to the beds occupying the same relative position in the east end of the Cypress Hills and north of Wood Mountain. The surface of this plateau is undulating and near the summit becomes very rough. Towards the east and north it slopes gradually down to the prairie level and no exposures occur. A thick bed of pebble conglomerate was found in a depression a couple of miles east of the west end of this plateau. This bed resembles exactly the Miocene conglomerate of the Cypress Hills, but it probably agrees more closely in age with the more recent deposits of a similar character found south of the "Gap" of the Cypress Hills, and in the valley of the Saskatchewan, which have been referred to the Pliocene. The beds underlying the conglomerate are not exposed but are probably Pierre.

East of this plateau an undulating plain, based on the Pierre shales, but affording no exposures, extends all the way to the White Mud River.

GEOLOGY OF WOOD MOUNTAIN.

Wood Mountain is simply a westward projecting spur of the Côteau Laramie area. Its geology is very simple, as the plateau is composed of an undifferentiated and conformable series of strata, referable in descending order to the Laramie, the Fox Hill and the Pierre shales. The whole system has a dip in an easterly direction, of about ten feet to the mile. Dip of system.

On approaching Wood Mountain from the north, along the Moosejaw and W.M. Mountain trail, exposures of rock are first met with in the vicinity of Twelve-mile Lake. This lake, which occupies the abandoned channel of some ancient stream, is hemmed in by high banks, which afford excellent sections of all the formations found in the district. Near its western end, the exposures consist of Pierre shales only, but

Formations
seen in Bound-
ary plateau.

Conglomerate

Age of con-

glomerate.

Geology

simple.

going east along the lake, the Fox Hill and Laramie descend successively to its level.

Pierre,
unfamiliar in
appearance.

Fossils scarce.

Boundary of
Laramie.

Decks
thin.

Pierre
irregular.

Exposures
small.

The upper portion of the Pierre shales, north of Wood Mountain, presents a somewhat unfamiliar appearance, where seen in the section around the lake and in the numerous coulées leading from the hills, as it has become greyer in colour and more arenaceous than the typical variety, and its foliation is also much coarser. These grey arenaceous shales are occasionally directly overlaid by the Laramie, but more frequently a varying thickness of coarse-grained, yellowish sandstone, representing the Fox Hill, intervenes between the two. Very few fossils were found in those sandy shales, but one section, after careful examination, in addition to some of the more common fossils of the formation yielded specimens of *Scaphites subgloboosus* and *Anchura Americana*.

In the western part of Wood Mountain, the boundary of the Laramie is coincident with the edge of the plateau, but farther east, owing to the easterly dip of the formation, it leaves the hills and turns away to the north, and at Twelve-mile Lake, the plain between it and the foot of the plateau is based entirely on the Laramie. This plain, which has a northerly slope of about fifty feet to the mile, is seamed in all directions by coulées issuing from the hills.

The Laramie strata north of Wood Mountain include three somewhat dissimilar groups. At the base there is a series of yellowish silts, silts and clays, holding small interstratified beds of ironstone, part of which may be referable to the Fox Hill. This is overlaid by a very conspicuous band of whitish and greyish argillaceous sands, silts and clays interstratified with a thick band of carbonaceous shales, which often includes a small lignite seam of inferior quality. This seam has been burnt in a number of places. The third group consists of yellowish silts and sandstones, with an occasional bed of hard nodular sandstone. Although none of the beds in this section maintain the same composition for any distance, and false beds are not other irregularities implying deposition in shallow water, are of frequent occurrence, yet the distinction between the different zones is remarkably persistent and holds good as far west as Cypress Lake in the Cypress Hills.

East of Wood Mountain Post, the plateau is extremely irregular and broken, a fact due to the multitude of streams and coulées which intersect it in all directions. The banks of most of these valleys are unfortunately, usually grass covered and the geological information they afford is very meagre and unsatisfactory. The few exposures which occur are very fragmentary and show yellowish and greyish silts, silts and sandstones, belonging to the upper portion of the Laramie. A thick bed of hard sandstone was found near the surface in a number of places and small beds of lignite are of not infrequent occurrence. The

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irreverence. The

most valuable seam that was examined is situated about eleven miles east of Wood Mountain Post, in Township 4, Range i., West of the 3rd Principal Meridian. This seam, which has been worked to some coal seam, extent, is about six feet thick and is of very fair quality. It is associated both above and below with sandy clays. The lignite from this seam was used with satisfactory results by the North-west Mounted Police for blacksmithing purposes, when they were stationed at Wood Mountain. A large stream of cold water collecting on the impervious surface of this bed issues from the bank and pours over its face near the place where it has been worked.

Another seam of a workable character was observed a few miles ^{coal seam} further west in Township 4, Range ii., West of the 3rd Principal Meridian. This seam is well exposed in the side of a hill south of the trail. The following section was measured here:—

	FEET. INCHES.
1. Yellowish sandy clay.....
2. Carbonaceous shale..... 2
3. <i>Lignite</i> 8
4. Carbonaceous shales..... 1 1
5. <i>Lignite</i> 4 6
6. Carbonaceous shales..... 1 0
7. Sandy clays.....

Going south from Wood Mountain Post, no exposures of any kind were met with until the southern escarpment of the plateau was reached. At this point, a thick bed of nodular sandstone projects from ^{Nodular} a slope near its bank, and above it small sections of yellowish silts ^{sandstone} and silts appear in the bank.

The southern edge of Wood Mountain plateau is low, is usually well exposed, and is consequently suffering little from denudation at present. It has been forced back to its present position by the united erosive action of Poplar River and Rocky Creek. These two streams are still separated by a low diffuse ridge, which is, however, rapidly in ¹⁸⁷⁰ degradation. The western slope of this ridge has been worn away by branches of Rocky Creek which penetrate it in all ^{Bad Lands} sections. The sections exhibited in these Bad Lands were examined by Dr. G. M. Dawson in 1874, and the following detailed description is quoted from his report*:—

"The most instructive section, however, in the Wood Mountain ^{Section 8 of} region, is twenty miles south of the settlement of that name, on the ^{Bad Lands} ^{of Wood} Mountains. Fifty-ninth parallel near the 425 mile point from Red River. Here beds undoubtedly belonging to the Lignite Tertiary formation—which, east

* *Geology and Resources of the 49th Parallel*, pp. 92-103.

Description of
bad lands.

of this locality has covered so great an area of country—are found clearly superposed on indubitable Cretaceous rocks. The exposures are numerous, and are produced by the streams flowing from the southern escarpment of the water-shed plateau, above referred to, which has here been gashed by their action into most rugged *Bad Lands*.

"This term has attached to it in the western regions of America, a peculiar significance, and is applied to the rugged and desolate country formed where the soft, clayey Tertiary formations are undergoing rapid waste. Steep irregular hills of clay, on which scarcely a trace of vegetation exists, are found, separated by deep, nearly perpendicular-sided and often well nigh impassable valleys, or, when denudation has advanced to a further stage—and especially when some more resisting stratum forms a natural base to the clayey beds—an arid flat, paved with the washed down clays, almost as hard as stone when dry, is produced, and supports irregular cones and buttes of clay, the remnants of a former high level plateau. Denudation in these regions, proceeds with extreme rapidity during the short period of each year, in which the soil is saturated with water. The term first and typically applied to the newer White River Tertiaries of Nebraska, has been extended to cover countries of similar nature in the Lignite Tertiary regions of the Upper Missouri, and other Tertiary areas of the west. In the bad-lands, south of Wood Mountain, the hills assume the form of broken plateaus; degenerating gradually into conical peaks, when a harder layer of sand-stone, or material indurated by the combustion of lignite beds, forms a resistant capping. Where no such protection is afforded, rounded *moat lumps* are produced from the homogeneous arenaceous clays. Waste proceeds entirely by the power of falling rain, and the sliding down of the half liquid clays in the period of the melting snow in spring. The clay hills are consequently furrowed from top to base, by innumerable runnels converging into larger furrows below. The small streams rapidly cutting back among these hills, have formed many narrow steep-walled gullies, while the larger brooks have produced wide flat bottomed valleys at a lower level, in which the streams pursue a very serpentine course. Denudation is even here, however, going on, as from the frequent change in the channel of the stream, it is constantly encroaching on the banks of the main valley, under-cutting them and causing land-slips. The method of the immense denudation of Tertiary beds, which is proved to have taken place over the area of the western plains, is explained by the degradation still going on in this way along their present borders.

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posterior to it. The masseteric fossa does not extend downwards to the inferior edge of the ramus. The latter is not inflected on the inner side as far posterior as below the middle of the coronoid process, where it is broken off.

Length of the dental series, M. .212; of true molars .085; of pre-molars .108; diameters of last true molar: anteroposterior .034, transverse .021; do. of canine at base: anteroposterior .040, transverse .029. Depth of ramus at M. 3, .086; length of symphysis .131.

This species was the largest flesh-eater of the White River Epoch, and the size of its canine teeth proves it to have been a dangerous animal. Its molars are interesting on account of their illustrating the most primitive form of a sectorial tooth.

PERISSODACTYLA.

MENODUS ANGUSTIGENIS, sp. nov.

This large Mammal is represented by numerous specimens. I select for present description two maxillary bones from the same skull, each of which contains the fourth premolar and the true molars; and two lower jaws from second and third individuals. One of these consists of little more than the symphysis. The other includes part of the symphysis, and part of the left ramus, which contains all the molar teeth except the first and last.

I refer the species to *Menodus*, because both lower jaws have, like the *Menodus giganteus*, Leidy, two incisor teeth on each side. The specimen in which the ramus is present has a small alveolus for the first premolar on each side; the side of the other specimen, where this part is preserved, has no such alveolus. These specimens show the identity of the supposed genus *Brontotherium* with *Menodus*. In the contracted shape of its mandibular symphysis this species resembles the species of *Symborodon* rather than the *Menodus giganteus*, and it resembles the smaller species of *Symborodon* in its inferior dimensions. It resembles the species of *Menodus* in the wide internal cingulum of the superior premolars. The species of *Symborodon* which present this character, are the *S. trigonoceras*, and the *S. heloceras*, Cope. Its measurements are inferior to those of the *S. trigonoceras*, and the superior molars are of different form. In the species just named their outline is oblong, the anteroposterior diameter exceeding the transverse in all three of them. In the *M. angustigenis* the molars are nearly square in outline.

The superior molars of the *S. trigonoceras* are characterized by the flatness of the middle portion of the external face of the external V's,

This surface is neither excavated, nor is it keeled, excepting a slight convexity on the middle of the anterior V of the first molar. The middle lines of the external faces of the Vs of the fourth premolar are slightly convex. There is a prominent vertical angle descending from the apex of each external V, and no lateral ones, so that there are no lateral pits at the internal base of the V on each side of the apex, as is seen in *Symborodon trigonoceras*. The internal cones of the fourth superior premolar, are not well distinguished. The only traces of cingula on the true molars are just in front of the median external vertical rib.

MEASUREMENTS OF SUPERIOR MOLARS.

	M.
Diameters of P. m. iv. { anteroposterior.....	.042
{ transverse.....	.054
Diameters of M. i. { anteroposterior.....	.055
{ transverse.....	.055
Diameters of M. ii. { anteroposterior.....	.071
{ transverse.....	.066
Diameters of M. iii. { anteroposterior.....	.071
{ transverse.....	.071

As already observed, the *symphysis mandibuli* is narrowed forwards, and it displays a groove on the middle line between the positions of the alveoli of the canine teeth. The sides of the ramus at this point are vertical, and a little concave above and behind the canine alveolus. In profile the *symphysis* slopes in an almost straight line from the bifurcation to the incisive border. There are two mental foramina close together. The anterior is the larger, and is situated a little below the posterior, and is below the anterior root of the second premolar.

The inferior canine is of moderate size, and the crown is recurved and is somewhat acuminate. The molars are narrow as compared with their length. Their crown consists of the usual two V's, except the anterior part of the second premolar, where the crest is only slightly concave outwards. The first premolar is represented by a single small alveolus. Anterior to it is a diastema a little longer than its diameter. Excepting on the second premolar, the external cingulum is complete and well developed on all the molars; (the last not present.) There is a very distinct, short cingulum at the base of the low anterior one of the three inner cusps, except on the second premolars.

MEASUREMENTS, MANDIBLES.

NO. I.	M.
Width between canines at exit from alveoli.....	.027
Length of premolar series.....	.088

ting a slight molar. The premolars are descending from that there are of the apex, of the fourth only traces of diian external

	No. II.	M.
Diameters of base of canine.	{ anteroposterior.....	.024
	{ transverse.....	.023
Length of premolar series.....		.098
Length of crown of P. m. i.....		.029
Diameters P. m. IV.	{ anteroposterior.....	.038
	{ transverse.....	.038
Diameters M. i.	{ anteroposterior.....	.050
	{ transverse.....	.031
Diameters M. ii.	{ anteroposterior.....	.064
	{ transverse.....	.041
Depth of ramus at front of M. ii.....		.086

When the bones of the skeleton in the possession of the survey are studied, a good idea of the proportions of this animal will be obtained. Its dimensions were probably about that of the Indian Rhinoceros.

M.
..... .642
..... .654
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M.
..... .627
..... .688

MENODUS. Sp. .

A second and larger species of this genus is indicated by numerous parts of several individuals. One of the most important of these is the superior wall of the skull complete from the end of the muzzle to near the inion, and bearing the lateral horns. This part shows that the species differs from the *Symborodentes trigonoceras* and *acer*, Cope, and the *Menodus ingens*, Marsh, in the absence of angulation above, between the free and other parts of the nasal bones. It also clearly differs from the *S. trigonoceras* in the semi-erect horns with little pronounced triangular section. From the *S. bucco* the lack of expansion of the zygomatic bones distinguishes it. As compared with the *S. altirostris* Cope, it has much longer and wider nasal bones, and the horns are more widely separated. The compression makes their apices anteroposterior, while they are transverse in the *S. altirostris*. In the uncertainty as to how this species differs from the *M. augustigenis*, except in dimensions, I postpone the description until I have access to all the material.

ACERATHERIUM MITE, Cope, Annual Report U. S. Geol. Survey Terrs. 1873, (1875) p. 493. Mandibular rami of two individuals.

ACERATHERIUM PUMILUM, Cope, American naturalist 1885, p. 103. (Name only.)

Portions of mandibular rami of two individuals represent this, the smallest of the Rhinocerontidae. One of the rami possesses the alveoli of the large recumbent canine teeth, indicating that the species is not a *Hyracodon*. The molar teeth are unfortunately broken away. The other ramus supports the third premolar, the last deciduous molar, with the first two permanent true molars.

The anterior (? first) premolar has a single large root, with a deep groove on the external side. In the true molars the V shaped crests are fully developed, and there is a low cross-crest at the anterior border of the crown. There is no complete cingulum, but short sections opposite the valley on both the internal and external bases of the crown, on the external side near the front, and at the posterior base. The measurements show how much smaller this species is than the *A. mite*, and that it does not exceed the *Hyracodon nebrascensis*.

MEASUREMENTS.

No. I.	M.
Width between bases of P. m. i.....	.033
Length of base of anterior 3 premolars.....	.042
Depth of ramus at diastema.....	.036
" " " third premolar.....	.042

No. II.

Length of molars i and ii.....	.039
Diameter M. ii. { anteroposterior.....	.020
} transverse.....	.012
Depth of ramus at front of M. ii.....	.033

ARTIODACTYLA.

ELOTHERIUM MORTONI. Leidy.

A superior molar and inferior canine teeth, represent this sline.

OREODON, or other genus of the Oreodontidae, is indicated by an inferior first premolar.

LEPTOMERYX MAMMIFER. Cope, American Naturalist, 1885, p. 163, (name only) with question as to the genus.

This species is represented by a fragment of the mandible which supports the last two molars. A tarsal cannon bone in the collection may belong to the same species. It is not certain that this ruminant belongs to Leptomeryx, but I leave it there until further information enables me to make a final determination.

The crowns of the molars are not prismatic nor are they brachydont. The crown is well distinguished, and expands but little. The sections of the internal columns are lenticular, while the external are crescentic. There are no basal columns or cingula between the latter. In the second true molar, the horns of the anterior internal crescent join the anterior external crescent early on wearing, while the junction

ot, with a deep shaped crests anterior border short sections al bases of the posterior base. is than the *A. nensis*.

comes later in the case of the two posterior columns. In the third true molar the anterior horn of the posterior crescent does not reach the posterior external column, but only touches the anterior internal column. In the same way, the posterior horn does not reach the external column, but is separated from it by a distinct mammary tubercle or short column, which has an anteroposteriorly short oval section. The heel of this tooth is broken off, but it was small, judging by the fragments of its base.

The peculiar column intercalated between the heel and the posterior internal column distinguishes this species from all the tertiary ruminantia known to me.

The enamel is slightly wrinkled. The half-worn condition of the crowns show that the animal was adult.

MEASUREMENTS.

	M.
Diameters of M. ii.	
{ anteroposterior0098
{ transverse.....	.0070
{ vertical (of enamel)0045

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1885, p. 163,

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The sections
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